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THE SUNDAL DRAINAGE SYSTEM IN CENTRAL NORWAY.

BY

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Introductory.—This paper originated in a study of Norway made in the geographical laboratory at Harvard College. From the laboratory I went into the field in the summer of 1897, and made a hasty examination of various points on the coast and on the highland of Norway, travelling by sea and land from Hardanger fjord in the south to Vardö in the north. The results obtained led me to concentrate my attention in the summer of 1898 on the region between the Romsdal and Trondhjem. Several rainy months flew by in the study of the valleys in this region, those of the Sundal system in particular. When the snow drove me from the field Dr. Hans Reusch, chief of the Norwegian Geological Survey, very kindly offered every facility for working up the results in Kristiania. Later on, before completing this paper, I had the advantage of talking the work over with Prof. W. M. Davis. Both Prof. Davis and Dr. Reusch have very kindly read and criticised the manuscript.

Valleys and Watersheds in Norway.—The two distinct sets of valleys which Prof. E. Richter* describes for southern Norway are well represented in the north. Everywhere comparatively shallow valleys may be seen mouthing high and abruptly on the walls of deep cañons. The southern high valleys, Richter says, are remnants of old and comparatively shallow valley systems which once headed near the present watershed of the country and drained west

* Geomorphologische Beobachtungen aus Norwegen, Sitzungsberichte der k. k. Akad., Wien. Math-naturw. Classe. Bd. 105, Abth. I, 1896, p. 147–189.

along the lines of the present deep fjords and fjord valleys. To-day's disjointed relation between the old high valleys and the young fjord valleys or cañons he explains by supposing that at various times during the glacial period the swifter and stronger ice-streams moved down the trunk valleys, while the slower and weaker streams followed the tributary valleys. As a result the trunk valleys wore down rapidly and began to break joint with the tributaries. At other times during this period, when the great glaciers retreated from the trunk valleys, névé continued to lie on the surface of the uplands and little glaciers gathered in the higher tributaries. Thus the trunk valley floor, exposed to the action of running water while all other parts of the system were protected by the ice cover, tended still further to break joint with the floors of the tributaries.

There are plenty of remnants of these old upland valley systems in the south between the Skager Rak and the Atlantic, heading on the main watershed of the country, and trending west. Similar remnants occur on the opposite side of the divide, trending southeast. These normal conditions—mature valleys heading on either side of the divide and draining away from it—appear to prevail as far north as the Ottadal (plate 1). Beyond this there is a striking change, which begins about 30 kilometres south of the mouth of the Romsdal, where the main watershed turns from a north and south line to one almost east and west. The watershed in the region of the Romsdal no longer lies between the heads of mature systems, one draining southeast and the other west; it lies instead on the floor of one of the southeast trunk valleys. The original heads of the southeast system lay many miles west of the present divide. These heads are now cut off from the southeast system, and drain as high valleys in a barbed or backhanded fashion into the deep young Romsdal cañon, whose stream flows northwest.

The New Boundary of the Sundal System.—North of the Romsdal system, and strongly resembling it, lies the Eikedal. Northeast of the Eikedal lies a variant from the Romsdal type, namely, the Sundal system, with which this paper is directly concerned. The gorges and cañons of the young Sundal system which drains northwest are divided from a certain mature valley system (hereafter called the Opdal system) which drains northeast and north, the streams from both systems reaching the Atlantic. The divide between them has suffered even a greater shift from west to east than was the case with the main divide in the Romsdal.

The object of the present paper is to present the arguments

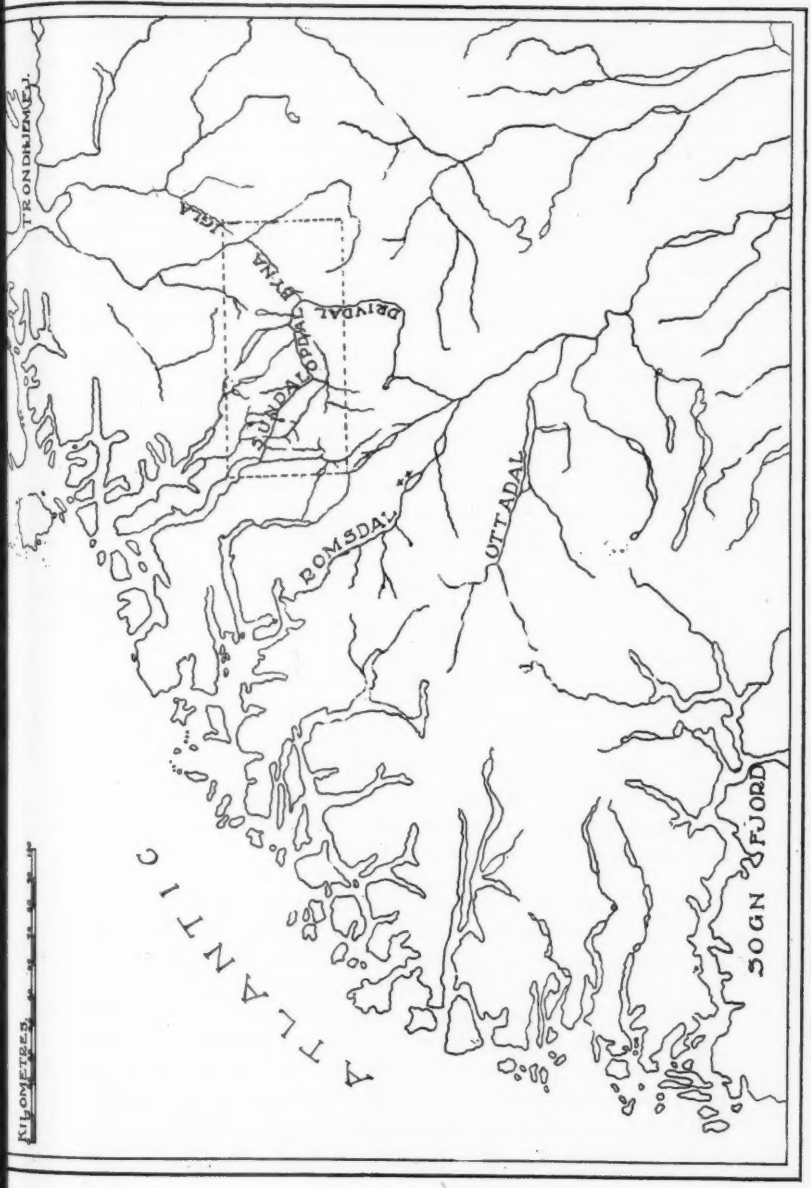


PLATE I.—OUTLINE DRAINAGE MAP OF CENTRAL NORWAY. THE RECTANGLE SHOWS THE AREA OF FIVE OUTLINE MAPS IN THE TEXT.

which have convinced me that the divide in question once stood near the head of the Sundal fjord, more than sixty-five kilometres west of its present position, which is just south of Aune in the mature trunk valley, and that the processes which shifted the divide are largely responsible for the peculiar features of the present Sundal system, with its cañons and high valleys.

My plan is: to reconstruct the mature valley system (Opdal) from its many disconnected ends; to describe the young cañon system (Sundal); to show the relations between the two; and to suggest explanations for these relations. Two sections headed "Details . . . ." contain accounts of certain items that are necessary to a full statement of the problem, but they may be passed over in a first reading.

Among the illustrations are five diagrams. On the first (Figure 1, plate 2), which is the name-key to the other four, there are several departures from the names given on the official map. For the sake of simplicity the names, North fork and South fork, have been applied to the branch cañons of the Sundal, and the name Gjeitdal has been extended to cover the lower as well as the upper part of a certain valley. The words, west and east, have been introduced at opposite ends of the Grödal for convenience in describing that valley. The suffix "dal" (valley), which appears in all the valley names on the key, has frequently been omitted in the text; the valley name being used alone.

The chief rocks, in the greater part of the region, which is shown in figures 1–5, are resistant archaean gneisses. Their folia have a fairly uniform strike across the region, about east and west, and a dip varying from perpendicular to nearly horizontal. The strike is crossed by the Sun and by some of the mature valleys diagonally. Others of the mature valleys are almost parallel to the strike, and still others cross it at right angles.

The Mature Opdal System.—The region is a highland, deeply dissected, but presenting comparatively even skylines. These become more and more even northeastward, as the surface falls off in height in that direction, until they form practically straight lines. Much of the highland surface is flat and quite as easy of access from the valleys as one valley is from another, but the highland does not attract farmers, for it is far too high to live on. In these latitudes there are few farms above 700 metres, and, as far as I know, none above 800; whereas the highland at its lowest is 1,300 metres and at its highest 1,800. It is almost absolutely barren; a high, cold

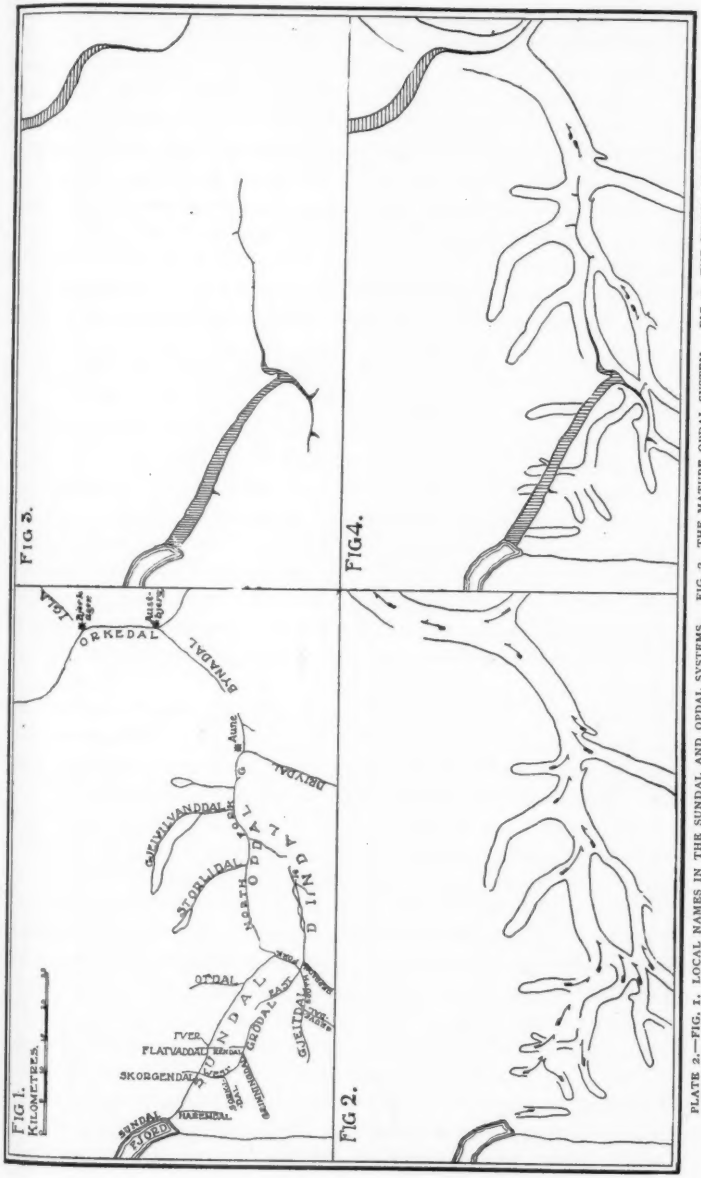


PLATE 2.—FIG. 1. LOCAL NAMES IN THE SUNDAL AND OPDAL SYSTEMS. FIG. 2. THE MATURE OPDAL SYSTEM. FIG. 3. THE YOUNG SUNDAL SYSTEM. FIG. 4. COMBINATION OF THE OPDAL AND THE SUNDAL SYSTEMS.

desert of rock and snow, relieved here and there by swampy or laked hollows. Although there is a vast quantity of fresh-looking rock waste over much of the surface, there is practically no fine soil. The cover of rock waste, attributed by Prof. A. Helland, of Kristiania, to frost work since glaciation, contrasts oddly enough with the bare rock in the floors of many of the high-level, mature valleys. In these, frost action seems to be much less active in splitting up the rock surface into coarse waste. The little fine soil which has formed has collected as black mud in the hollows, leaving much of the rock bare. The little mare which carried my pack, and was my only companion during a large part of the summer's work, could testify to all this; to the bleak highland, on the lower parts of which she spent more than one cold and hungry night, and to the equally bleak valleys where she found the edible grass blades—when there were any—growing a yard apart, and where she sometimes slipped and fell on the smooth, bare rock trails, and often had to struggle through the deep, sticky mud in the hollows.

The high-level valleys which are sunk beneath the highland in this region are of mature expression. In no sense are they valleys belonging to a peneplain, such as the highland may have been. If the highland country in which they lie has ever been a peneplain, it must have been greatly uplifted to enable the valleys to attain their present depths, and must have stood at the level then reached for a considerable time, to enable the valleys to attain their present low grades.

The high-level valleys of the region under consideration are not immediately connected to-day, but a study of their relations to one another shows that they once belonged to a large mature valley system which drained east and northeast from sources in the highland over the head of the present Sundal fjord to a station, Stören, some distance down the trunk valley of the mature system. Figure 2 (plate 2) shows this system from its western valley heads to within a few miles of Stören. The original plan of drainage and the relations of the various fragments to the system as a whole are shown by arrows. The accordance of the various valley floors throughout the system, despite the disconnected condition of the parts, is very striking. Practically all the heights along the floor of the trunk valley and along the floors of the connected and disconnected branches, except in one or two places where glacial obstructions occur, accord with the descending slope of a single valley system made up of all these pieces, as is shown by the altitudes on figure 5. Moreover, all the branches, except two short gulleys (H in the Din and G opposite

the Gjeivilvand, figure 1), which appear to have been worn in fractures, trend in sympathy with, or at right angles to, the trunk of the system.

The lower part of the trunk valley is a broad, shallow, well-matured valley, incised in a particularly smooth part of the highland, which slopes gently down to the northeast. The upper part of the trunk valley and its branches are by no means as well matured as the lower. As a rule they are deeper and more steep-sided than the latter. Their steep-sidedness is appropriate in any case, as the lower course of a valley system always matures before the upper course. Their greater depths are due to the fact that while the grades throughout the system are fairly uniform, the high-

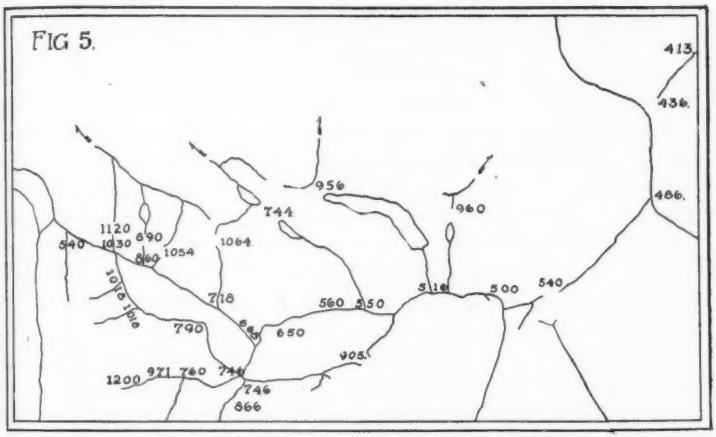


FIG. 5.—ALTITUDES, CHIEFLY IN THE ODAL SYSTEM.

land in which the upper part is incised is very much more elevated than that in which the lower part is incised.

The rather gentle side-slopes of the shallow lower trunk valley were once heavily timbered, but are now more or less cleared of timber and used for hayfields. As the valley system ascends, its floor gradually rises above timber-line. Its uppermost parts, if bearing any trace of man at all, have nothing more than small rough stone huts, which afford a night's shelter to the passing hunter. A little lower down appear the saeter huts, where the women live in summer to milk the cows pasturing there and to make cheese and butter from the milk. Still lower down, the farms begin to appear; at first few and far between, then closer and closer

together, until in the better-preserved middle part of the system a large portion of the broad valley floor is covered with farms and traversed by roads connecting them. All this stands in striking contrast to the entirely uninhabited highland surface in which this valley system is incised.

Being to-day composed of disconnected parts, this valley system, of course, has no one name, but instead a different name for every separate part, as may be seen by comparing figures 1 and 2. I shall call it for short the Opdal system, after the name of the most populous part of the trunk valley.

The Young Sundal System.—Turning now to the young cañons and gorges, represented alone in figure 3, plate 2, attention is first attracted by the great Sun cañon. The Sun extends, in southeastward continuation of the somewhat sinuous Sundal fjord, as a remarkably straight, broad and deep cañon for more than thirty kilometres through the highland. The cañon's floor near the fjord is eighteen hundred metres below the highland surface and more than one thousand metres below the floor of a certain high valley, a detached fragment of the mature Opdal system, which here mouths abruptly on the wall. The relief decreases somewhat up-stream as the highland surface falls off in that direction. Moreover, the highland south of the cañon, in this upper part, is lower than the highland north of it, because of a *graben*-like depression of the highland surface which lies between the Sun and the Grö.

The walls of the cañon are very steep, often inaccessible to within a hundred metres of the actual surface of the highland, where they flare out. The talus is scanty as a rule, and varies greatly in quantity from place to place. When present it is clothed with small trees and bushes on its lower slopes, but its upper slopes and the cliffs above it are bare. Here and there talus is altogether lacking, and the bare rock appears, smooth as if ice-rubbed. The cañon is floored with a flat drift plain, terraced by a stream which still runs on the gravels in a steep-sided trench. There is a quiet little village on the gravels at the cañon's mouth, and the broad plain back of the village is covered with farms and traversed by several roads. As the plain narrows up-stream, the farms become fewer and the several roads merge into the main highway.

Details of the Sundal System.—The average cross-section of the cañon is approximately that shown in figure 6. There is, however, a marked departure from this cross-section in the portion between

the western Grö and the Harem. Here the southern side retreats, as shown by the dotted lines, and a strong cliff (A) extends parallel

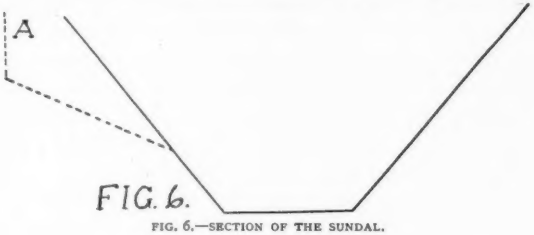


FIG. 6.—SECTION OF THE SUNDAL.

to the Sun from the Harem to the Grö. A weaker cliff but one on the same line as the other appears across the western Grö (B, figure 7). A short distance up the western Grö from the cliff, a fresh-

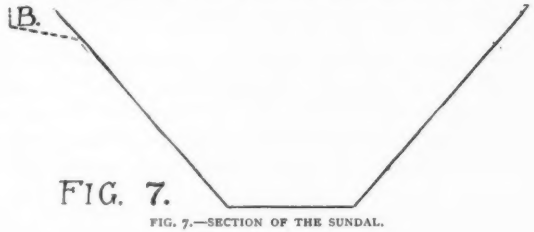


FIG. 7.—SECTION OF THE SUNDAL.

looking crack, along which there appears to have been a slight vertical movement, crosses the valley on a line parallel with the cliff. The crack and the cliff, both thus approximately parallel to the Sun, taken in connection with the curious one-sided broadening of the Sun itself, between the Harem and the Grö, are suggestive of a small *graben* here.

The deep and wide part of the cañon which I have been describing thus far heads abruptly against a low part of the highland; another *graben*-like depression. Branch cañons lead off at right angles to the north and south. These are much shallower than the main, because they are cut in the floor of the mature trunk valley of the Opdal system instead of directly in the highland. They are also much narrower. The one trending north, the North fork cañon, continues, drift-floored and habitable, for a few kilometres up-stream from the branching point. Then it swings round to the east and changes rather abruptly into a much smaller and generally narrow, uninhabitable stream-cut gorge, which extends on up to Aune in the mature trunk. As this narrow gorge is incised in a valley floor, which becomes

lower and lower as it descends in the opposite direction to that in which the stream flows, the gorge shallows rather more rapidly than it otherwise would. Three very short branches lead off—one toward the Storli, one toward the Gjeivilvand, and one toward the Din. The South fork cañon, like the North, continues drift-floored and habitable for a kilometre or two up-stream, and then passes into another narrow, uninhabitable stream-cut gorge. The gorge swings round to the west and extends far up into the Gjeit, with a small branch in the Din and another in the Gruve.

A very striking feature of the Sun and the North fork, which together constitute the trunk cañon of the young Sundal system, is the habit of their tributary streams from the high mature valleys to trend, like barbs, out of sympathy with the trunk. This young trunk cañon, with its various branch cañons and the numerous high fragments of the ravaged old Opdal system, which now discordantly drain into it, constitute what I have called the Sundal system.

The Young Orke System.—There is another cañon, called the Orke, similar to the Sun, but shallower, which lies in the eastern part of the region. Like the Sun's forks, the Orke passes rather abruptly into a narrow, uninhabitable gorge, which extends from Austbjerg to Bjerkager and beyond (see figs. 1 and 3).

Relation of the Orkedal and Opdal Systems.—Thus far I have described the young Sundal and Orke systems and the mature Opdal system separately. Now, I propose to show their relations, as summarized in figure 4, plate 2. The lower trunk of the Opdal system appears, from most points of view, to be one continuous old valley. As a matter of fact, however, a stream from part of it escapes northward through the Orke cañon, which pierces the trunk valley side at Bjerkager; while a beheaded lower stream continues in the mature trunk valley, here called the Igla, toward Stören. The floor above Bjerkager, as before stated, is trenched by a narrow gorge, the continuation of the Orke cañon, as far as Austbjerg. The remnant lateral benches of the mature floor, each traversed by a road and occupied by farms, and the medial gorge, uninhabitable and impassable, between them, stand in striking contrast to each other. At Austbjerg the gorge switches off up a branch valley to the southeast, leaving the up-stream floor of the mature trunk valley intact, not trenched at all.

The stream in the trunk valley above Austbjerg is called the Byna; it is very small, and totally out of proportion to the valley. The size of the valley would lead one to expect, instead of a small,

weak stream, a large river, well able to trench its valley floor. In fact, it can hardly be doubted that the Opdal trunk was once occupied by a large river flowing northeastward, whose upper waters have since been directed to some other discharge.

The Sundal and the Opdal Systems.—The diverted part of the Opdal drainage comprises, as may be seen by comparing figure 2 with figure 4, all the water south and west of Aune which to-day escapes westward in the gorges and cañons of the Sundal system. The diversion, as before stated, appears to have resulted from a shift of the Sundal-Opdal divide from its original position in the highland above the head of the Sundal fjord to its present position in the floor of the Opdal trunk near Aune. The divide lies to-day about six kilometres northeast of Aune on glacial material, which buries the rock floor at this point to a depth of thirty metres, or more.

A small branch valley just east of Aune trends in sympathy with the old system. Its stream, however, on entering the trunk, instead of finding a master flowing northeast, as it probably did before the above-mentioned changes, finds a very different state of things. It now joins, as a barb, a small stream heading on the modern divide of glacial material, and flowing backward into the head of the North fork gorge. The gorge leads the water west through the floor of the Op to the Sun. The large Driv also trends in sympathy with the Opdal system, and when seen from near Aune looks as if it must have been a branch of the trunk valley. Its stream, however, instead of flowing on down the trunk valley, as it doubtless once did, now bends sharply round, barb-fashion like the other, and flows with it into the North fork gorge.

The Op, in whose floor the upper part of the North fork gorge is cut, seems unquestionably to be a part of the trunk of the mature Opdal system. As has already been said, the floor of the mature trunk, formed by the Op and the various other valley sections, rises almost continuously from its lower part by Stören, to the southwest and west. There is but one exception to the general rise, namely, the divide formed just below Aune by glacial gravels, but these very probably overlie an uninterrupted rock slope. Four large tributary valleys enter the Op section at its floor-level. Three of these trend in sympathy with the trunk valley and one at right angles to it. Their streams fall, three of them barb-like, into the North fork, which leads their water west against the slope of the floor of the mature trunk valley.

The North fork gorge is very shallow near its head, hardly to be suspected in the broad Op floor. As it grows deeper and more

cañon-like westward, it becomes broader and more conspicuous; while the mature floor which once stretched all across the valley dwindles away to comparatively narrow and somewhat dissected benches on either side.

The broad, mature floor of the trunk valley and its branches in the Op section are occupied by farms and by roads connecting them. Several farms stand abreast in the lower part of the Op. As, however, the uninhabitable gorge gains in size westward, the farms are forced into single file on the narrow remnant benches of the mature trunk valley. One good road on the north and a bad one on the south suffice to connect them. As the lower part of the North fork is approached the highway on the northern bench descends, cutting its way in the cliff on the side of the gorge. It reaches the bottom just where the drift-plain begins. Soon after the road descends from the northern bench, the farms disappear from both benches and saeters only remain.

The mature trunk now swings round to the south along the line of the lower North fork. The continuation of the northern bench in this quarter becomes indistinct for a time, but presently reappears clearly in the shape of a long, flat-topped spur in the angle between the North fork and the main Sun. The spur corresponds to a broad, continuous bench which lies along the eastern side of the North fork, across the head of the Sun and along the eastern side of the South fork; also to a bench on the western side of the South fork.

The spur apparently lies where the mature trunk was joined by a branch coming from the west, along the line of the Sun. There are suggestions of remnant benches of such a branch valley even along the Sun's sides, but these are very faint and not to be depended upon. Remnants still more striking than benches, however, remain to mark a mature branch that has been destroyed by the erosion of the Sun cañon. These are an ascending series of high valleys which mouth abruptly on the Sun's northern wall (figures 2, 4, 5). The first one mouths at seven hundred and eighteen metres, fifty metres higher than the top of the spur, the next at eight hundred and sixty metres, and the next at ten hundred and thirty metres. All three have low grades, head on low divides, and trend in sympathy with the supposed branch. The Ot and Flatvad have cross sections like that of a deep bowl. The Skorgen's cross section is like that of a shallow bowl. Both the Skorgen and the Flatvad are very much shorter than the Ot. A fourth valley, the Sorkj (not Skorgen), also appears to be a frag-

ment of the mature branch. It is one of the short, broad, shallow-bowl type. It trends in sympathy with the supposed mature branch and mouths high (ten hundred and thirty metres) and abruptly on the western wall of the western Grö. The western Grö, as stated above, enters the Sun at the floor-level of the latter as a deep young V, the only low normal tributary to the cañon on its whole course of thirty kilometres. In brief, the suggestions are that when the Opdal system was intact it had a long branch on the line of the Sun (but at a higher level) with all these short tributaries. To-day the floor of the branch is gone, and instead one sees the deep, young Sun cañon and its off-shoot, the western Grö, with the short tributaries mouthing high and abruptly upon their sides.

The Sun cañon not only runs the whole length of the lost branch of the Opdal, but also penetrates the floor of the mature Opdal trunk at the point where the lost branch once joined it. To the north and northeast extends the North fork cañon, which has already been described. To the south and southwest one can see the remnant benches of the partly matured trunk valley, with the South fork cañon between them. This cañon narrows and shallows up stream until it finally dies out far up the Gjeit, where the partly matured valley remains intact.

Details of the Grö, Din and Gjeit Valleys.—The eastern Grö, a low-grade valley, with a shallow-bowl cross-section, mouths abruptly on the southern wall of the South fork just before this cañon turns up the Gjeit. The eastern Grö's stream heads on an almost imperceptible divide, flows for a few kilometres on the gently sloping floor, and tumbles in a waterfall into the gorge. The very similar Din mouths opposite at the head of a short branch gorge; and between the Din and the Gjeit mouths the somewhat deeper and narrower Reppa. All four valleys mouth thus like spokes in a hub—three on the gorge and one with the gorge in its floor, as close together as they can squeeze in. This disposition of valleys is abnormal. It is probably due to the inosculation of two parts of the mature Opdal system; an extended Gjeit, forming the upper trunk of the system, and a Reppa-Din branch (figure 2).

The Din, although it bears but one name, has a low divide on its floor, from which one stream flows east and another west. It is what Richter calls a "double valley." The divide lies on glacial gravels which fill the valley from end to end. They may have been poured in at a curious opening (I on the key) in the southern wall

which affords connection with high collecting grounds for snow. The gravel deposits are eroded, but little if any in the central portion; but at the mouths of the streams they are trenched down to the rock floor, some sixty metres below their surface. Much of the deposit between the divide and the western mouth was apparently formerly pitted with deep hollows and the hollows were filled with lakes. Since then the lakes have lowered their outlets in their kame-like barriers, and nothing now remains but a set of very shallow, almost streaming, water bodies. There is every reason to suppose that no divide exists on the rock floor itself under all these gravels, but that there is instead a continuous slope from the present visible rock floor in the western end down to that in the eastern end of the valley. If this is assumed to be so, it is necessary only to replace in imagination the lost part of the dividing wall between the Reppa-Din and the extended Gjeit to show what an appropriate head for the Din the Reppa is. The rock floor in the Reppa's mouth is practically at the same level as that in the Din's western mouth, a trifle higher if anything, and the trend of the valley is just as it should be to fit the Din. The Reppa-Din thus reconstructed would make a branch to the mature Opdal system, trending in perfect sympathy with it. On the other hand, if it is supposed that there were no Reppa-Din, but that the greater part of the Din drained west as now, the Din would have joined the extended Gjeit part of the mature trunk valley as a barb, trending quite out of sympathy with the Opdal system. It would have then formed one of the four valleys which to-day mouth abnormally, close together—three on the gorge and one with the gorge in its floor.

The Din for some reason is occupied by saeters only. Its former head, the Reppa, contains but one even of these, probably because of its depth and narrowness. The lower Gjeit is deserted because the gorge occupies most of its floor. A graben-like broadening in the central part of the last-named valley is, however, occupied by farms, and there are saeters where the intact floor of the upper part begins. In the mouth of the eastern Grö there are several farms, and up the valley are numerous saeters. The various benches between the mouths of the four valleys support two or three isolated farms.

The name Grö, like the name Din, applies to a double valley, with streams draining either way. On the flat divide in this valley, unlike that in the Din, bare gneiss appears through the glacial gravels. Just east of the divide the valley makes a sharp angular

turn from east to south (figure 2). East of the turn a cross-section is like that of a shallow bowl. West of it the valley is broader still, with a cliff on the south and a rather gentle slope most of the way on the north. The floor has little slope either way for several miles. Some distance west of the divide the valley begins abruptly to deepen. It passes into a very deep, narrow U and curves round north as if about to mouth abruptly on the Sun's southern wall, like the Ot on the northern wall, but much lower than that valley and at about the same level as the Harem. It does not reach the Sun's wall in this form, however, for a narrow cañon starts in its floor two or three kilometres back from its mouth. This cañon widens and deepens towards the Sun, and as it does so the benches of the U floor on either side dwindle and finally disappear. The valley, instead of mouthing on the Sun as a high U, enters, as already stated, as a low V about at the Sun's present level.

A valley called the Grinning, whose cross section is like that of a shallow bowl, mouths abruptly high up the side of the deep narrow U of this western Grö, just where the U begins to swing round from west to north. The deep U thus intervenes between the shallow Grinning and the shallow central part of the Grö. The Grinning trends so nearly in the same direction as the central part of the Grö that one standing on the Grö's divide and looking west gains the impression that the Grinning is a detached fragment of a former Grinning-Grö branch of the Opdal system.

High-level Tributaries of the Sun Cañon.—The tale of the double valleys does not end with the Grö and the Din. The Ot, the Tver, the Flatvad, the Ren, and the Skorgen are all double valleys. Perhaps the most notable of the five is the Flatvad. It is a remarkably straight, deep, north and south trench, with an almost imperceptible divide, not two kilometres from the Sun. It mouths abruptly at both ends on cañon walls. Exactly opposite this valley across the Sun mouths the Ren. The Ren is a small double valley between the Grö and the Sun, trending in about the same direction as the Flatvad. An example of a different type is the Skorgen. The ascent to this valley from the Sun is very steep, like that to the Flatvad. The valley floor is fairly flat for several kilometres. Beyond this the floor rises abruptly in a vast wall, perhaps 100 metres high, which, save for a breach near its eastern end, completely blocks the valley. The traveller passing through the breach or climbing to the top of the wall and looking north finds himself on the edge of a great amphitheatre, whose floor lies three hundred

metres below him. The valley looks as if made by two cirques at different levels, which wasted backward towards each other until the dividing wall between was breached, or until some other process than the wasting breached it. As in the case of the Flatvad, so here, there is a corresponding valley across the Sun directly opposite, namely, the Grö. But the Grö, unlike the small, shallow Ren, is a large, deep valley.

Thus far I have traced the mature system up the Gjeit, up the Grö to the Grinning, and up the Sun to the Skorgen and Sorkj. In so doing I have considered all the important valleys in the western part of the region under discussion except one—the Harem.

The Harem is a tributary to the Sun close to the fjord. The valley mouths at right angles to the Sun five hundred and forty metres above the floor of the latter, that is, at about the level the deep U of the western Grö would have if it reached the Sun's wall. The Harem is the deepest of all the high valleys. Its floor is one hundred and seventy metres lower than that of the Ot, the lowest of the high fragments of the Opdal system, and five hundred metres lower than that of the highest, the Skorgen. It is about as long as the Ot, and has a similar cross section, a deep U, but its fall from head to mouth is twice as great. The descent is chiefly in two steps, one of them very strong. Between the steps the valley is of rather low grade. The top of the upper step is the very high flat floor of a valley draining in the other direction. The extraordinary depth of the Harem and the Grö, as compared with the various valleys of the Opdal system described above, is rather remarkable. Possibly they once belonged to this system, but have since been acted on by ice, or some other agency, much more violently than their sister tributaries. Possibly the Harem belonged to a contemporaneous system draining northwest along the line of the present Sundal fjord. Such a system as this latter must, of course, have been very much shallower than the present fjord. On the other hand, it must have been much more deeply incised at its head than the mature Opdal system, which drained in the opposite direction.

Summary concerning Reversal of Drainage.—What I have tried to establish thus far is as follows: There was a large mature (Opdal) valley system rising in the highland over what is now the head of the Sundal fjord and draining east and northeast towards Stören. There was another system contemporaneous with this but deeper in its upper tributaries, which rose close to the head of the first and drained northwest to the sea. The divide between the two

has shifted to such an extent that the greater part of the large mature system which formerly drained east and northeast now drains west against its old slopes in deep, young gorges and cañons. As the gorges and cañons deepen downstream through the rising head valleys of the Opdal system, the main Sundal cañon comes to be one thousand metres deeper than the highest head valleys that it dissects. In the cañoning, large portions of the mature valley floors have completely disappeared; and narrow benches alone remain to mark them elsewhere. In some of the larger branches of the mature system, that over the Sun in particular, the entire floor has disappeared, and the tributaries are left as isolated fragments of the lost branch, hanging up high on cañon walls.

Explanation of Reversal of Drainage.—Now that the main facts regarding the reversal of the drainage have been set forth, with such explanation of curious details as seemed necessary, I have some suggestions to offer as to the explanation of the reversal. It is manifest that the chief change occurred in the highland on the line of the former Sundal-Opdal divide, and especially where the great Sun cañon has been eroded across the divide. Several factors occur to me as probably instrumental in this change, namely, guided headward erosion by the Sundal system and capturing of the Opdal branches; unguided headward erosion and capturing; erosion by the outlets of ice-dammed lakes which overflowed from the Opdal system to the early Sundal system; and glacial erosion.

The general form of the land suggests headward erosion and capturing on the part of the early Sundal system, for the slopes on the west are steeper than those on the east, and the distance to the sea is shorter. These conditions prevail only in the reversed drainage area of central Norway north of the Ottadal (plate 1). South of the Ottadal, where there has been no reversal of drainage, the slopes and distances to the sea east and west are much more nearly equal.

The region is full of suggestions of fault lines. Most important among these are the boundaries of two large *graben*-like blocks mentioned above as lying low in the highland. Along these boundaries four of the more important of the valleys discussed have been excavated. Two of the valleys are notable for their angularity, and the third, the Sun, for its straightness. Headward erosion, guided by some of these lines of weakness, or even unguided erosion through the massive rock, might seem a reasonable process of capture and reversal of drainage were it not for the following important

feature, which argues against the occurrence of either of these processes on a large scale: None of the diverted high-level tributary streams have trenched their floors to any considerable extent, and the smaller of them have not trenched at all. This quite excludes capturing from the upper part of the Sundal system, where the larger tributaries occur; for no one would believe that the slow process of headward erosion had power to cut a long cañon like that of the North fork, while a large diverted tributary valley like the Storli, whose mouth has been passed on the way, remains practically untrenched. On the other hand, the capture of the smaller high-level tributaries of the Sun cañon by headward erosion, although unlikely, is not altogether excluded. These tributaries are very weak and have little power to trench. The short trenches that they did cut, if they cut any, may well have been obliterated in a subsequent widening of the Sun cañon by ice. It seems, however, impossible, even in this district, to say how much capturing by headward erosion took place. Headward erosion and capturing thus appear uncertain in their application.

The ice of the glacial period has wrought many and great changes in all the valleys before and after the completion of the reversal of drainage, for every one of the valleys bears the mark of ice erosion more or less deeply. The shapes of most have been changed from the V section to the typical U section. The floors of some have been furrowed as if by a gigantic plough; and one long deep valley which lies at right angles to the ice movement has come to exhibit enormous examples of *roches moutonnées*.

But the first cause of the drainage reversal seems to me to be the overflow of ice-dammed lakes. If it is assumed that the mature Opdal system was practically intact in its western branches when the ice-sheet appeared, it is probable that a series of events somewhat like those set forth in the following paragraphs took place:

Reversal by Overflow of Ice-dammed Lakes.—As the glacial period came on, a vast quantity of water in east-sloping valleys was dammed back by the ice and forced to flow out to the west over cols in the highland; the Sundal cañon not yet being begun. As the ice-sheet advanced on the lower Opdal system, outlets from the heads of high-level valleys were found to the northwest. The first of these were closed as the ice continued its advance, and others further west at higher levels were chosen by the water. The Ot, for example, formed an outlet after the mouth of the Storli was closed. The Ot—then, doubtless, a normal tributary to the Opdal

system—is now a double valley. It mouths on the north at the floor-level of a valley draining northwest, and on the south high up the Sun's wall. The next outlet, after this was closed, was through a gap in the highland where the Flatvad and the Tver are now. Previously streams in this gap had doubtless flowed south and joined a master in the normal way. Both masters must then have been at the level of the streams in question. To-day four of these streams run in two parallel double valleys. One of them so closely resembles a single valley that the one name—Flatvad—covers the whole. Both valleys mouth high and abruptly at either end on cañon walls, and their streams go tumbling down long distances in cascades and waterfalls to find their masters. Directly opposite the Flatvad, across the Sun, mouths the double Ren. Further west on the Sun, in a similar relation to each other, mouth the Skorgen and the western Grö. The Skorgen is a double valley, although of a different type than the Flatvad, and the double Grö mouths exactly opposite. The Grö to-day, to be sure, mouths many metres below the Skorgen, but this deepening may well have taken place since a time when the two were near a common level. As an outlet from an ice-dammed lake formed in the Grinning-Grö to a similar lake in the mature branch over the Sun, the then eastern Grö must have been shallow.

The form of the Flatvad and the Ren and the relations among all four valleys recall in a general way the cross valleys in central New York, described by Gilbert, Quereau, and Fairchild. In the neighborhood of Syracuse there are a number of streams flowing north in deep valleys between the spurs of an upland that slopes to the north. Through the spurs run several channels, opening at either end above the floors of the north-draining valleys, and sloping gently from the valley on the west to that on the east. The floor of each channel is higher than the upland surface about the channel next north. The channels between any one pair of north-draining valleys are roughly in line with those between the next pair. It is supposed that these channels were formed during the retreat of the North American ice-sheet by the overflow of the water along its southern margin.

The Norwegian cross valleys, in so far as they are due to the overflow of lakes dammed back by ice, were probably cut during the advance rather than the retreat of the ice. For when the water rose high enough to flow out directly west, the cutting of the present Sun cañon started and the level of the water began to be perma-

nently lowered; hence on the retreat of the ice the Sun cañon would retain the overflow.

Erosion by Overflowing Glaciers.—Ordinary stream erosion ceased when the glacial sheet overspread the whole region, but then the ice and the streams under it continued the work that the lake-overflows had begun. Ice-streams doubtless crept through every valley in the region, whatever the relation of the valley's direction to that of the general movement, uniting, dividing, and uniting again until they reached the sea. The overflowing ice planed out the gorges which had been cut across the cols in the high-level valleys by the overflowing water. It ground the valleys down until their cross sections assumed the form of a shallow bowl, or deep bowl, or deep "U," according to local controlling conditions. Among these conditions were: the depth to which streams had already eroded trenches in the cols, and the relation between the direction of a valley and the direction of the chief glacial movement. The former condition would not only determine the form of a valley when the ice came upon it but also the thickness and weight of the glacier starting through it. The latter condition would determine the velocity of the ice movement. Two of the high-level valleys in the region which lie nearly at right angles to the general ice movement still retain the breaches in their cols; not sharply-cut gorges, to be sure, but narrow, ice-rounded troughs, as if the ice had at least been over the col but not in sufficient force to obliterate the gorge. If this much is true, it seems reasonable to go a step further and suppose that the amount of the discordance between many of the high-level valleys and the Sun is largely dependent on the relation between the weight and the direction of movement of the glaciers in the high-level valleys and the weight and direction of movement of the glacier in the Sun. It certainly seems probable that the Sun's floor began to break joint with the floors of its tributaries in this glacial stage of its development. It doubtless continued to sink below them even after the ice-sheet spread down to the sea, covering the entire surface, highlands and valleys alike, for the probable effect of the ice-sheet was to emphasize inequalities in the surface rather than to obliterate them. The weight being least on the highest surfaces, the ice probably did least erosion there. Being greatest in the deepest troughs, it probably did more erosion there. A trough already deep and parallel to the ice movement, like the Sun (parallelism as well as depth being a condition most favorable to the ice action), probably suffered the most intense glacial erosion.

When the ice retreat set in, the deepened western outlet by the Sun cañon came into play again. All the water in the region—a large quantity—drained out through it and doubtless deepened it a great deal. The insignificant streams once existing on the lines of the old high-level outlets returned, but did little excavating. They came tumbling down the wall of the new-made cañon in waterfalls, and perhaps cut short branch cañons of their own; but if they did, these were entirely obliterated by a second great glacier which, during another ice advance, ran through the Sun.

The cutting of the western Grö by stream erosion went on in much the same way as that of the Sun, and continued until the present Grö, or rather the Grö as it would be without the cañon in its floor, resulted. Probably about this time, or at any rate before the post-glacial cañon in the North fork was cut, water work again ceased throughout the system and another set of glaciers crept down to the sea.

This time a giant Sun glacier, formed by the confluence of smaller glaciers descending from the Op, the Gjeit and the Reppa, appeared and swept down past the mouths of the Op, the Grö and the Harem, with their pigmy glaciers. It is probable that these three valleys had not thus far broken joint with the Sun. But now, with the advantage already gained by the stream erosion plus the increased power of the glacier itself, the Sun glacier was able far to outdo all the little glaciers. It probably planed down the cañon's floor much deeper below the floors of the tributaries than the water had cut it. It certainly widened the cañon and steepened its side and end walls in a remarkable manner. When the ice departed, both side and end tributary valleys were left hanging high up on the Sun walls. The tributary streams when released all strove to trench. That of the South fork cut a long gorge, that of the Grö a short one, and those of the others none. The lake, still dammed by ice in the North fork, overflowed and cut the gorge described as reaching nearly back to Aune. When the lake disappeared, the Driv, instead of flowing down its old valley, found its way out through the gorge, thus completing the reversal of the Opdal system.

PORTO RICO: ITS TOPOGRAPHY AND ASPECTS.

BY

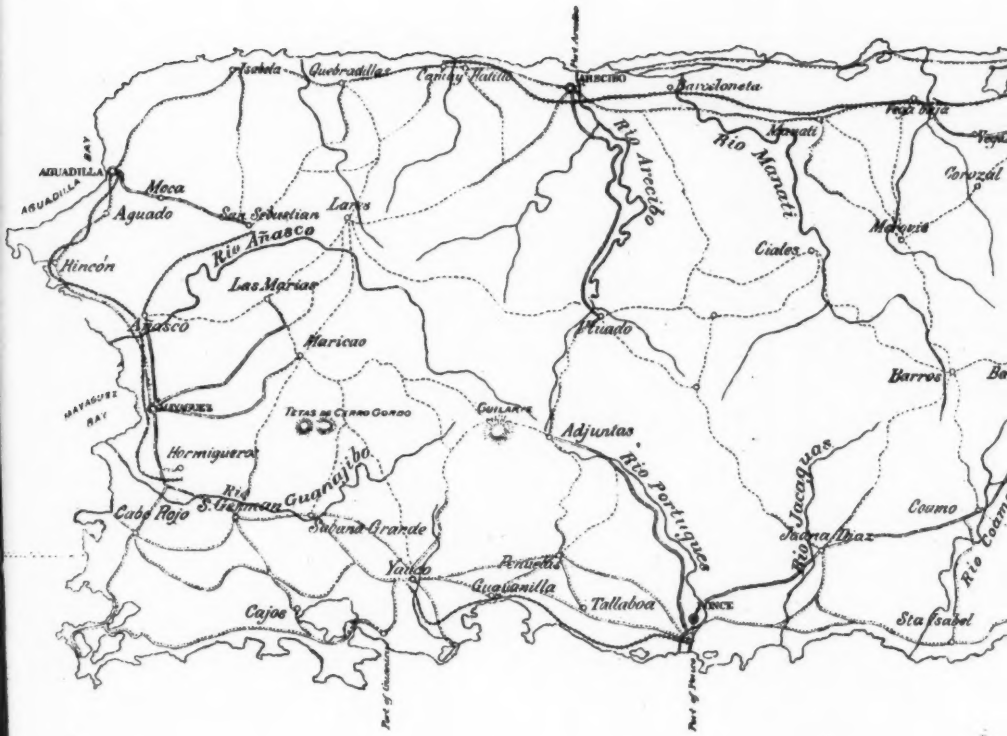
HERBERT M. WILSON,

U. S. Geological Survey.

The peace protocol had scarce been signed ere the American Government, with the energy and thirst for knowledge which characterises our people, commenced a scientific crusade against the oblivion which envelopes our knowledge of the resources of Porto Rico. The Smithsonian Institution sent expert collectors to gather information, especially articles for museum exhibit, illustrating the ethnology, anthropology, mineralogy and all historical, manufacturing and natural resources. The Fish Commission dispatched on the steamer *Fishhawk* an expedition composed of the flower of its scientific corps for the study and development of the fresh and salt water inhabitants of the island. The Coast Survey dispatched their steamer *Blake* to chart the coast and harbors of the island and the Geological Survey sent representatives of its most important branches to make a reconnaissance examination of those resources coming under its jurisdiction.

In company with Mr. Robert T. Hill, Geologist, I was thus afforded an opportunity of travelling, chiefly on horseback, throughout the interior of Porto Rico. Mr. Hill, probably the highest authority on West Indian geology, was assigned the duty of making a reconnaissance report on the geological and mineralogical resources of the island. I was assigned the duty of examining the interior, with the view to commencing a topographic survey, in addition to gathering data relative to the hydrography or water resources. We both paid considerable attention to the forestry and agriculture, and recorded our observations not only in note-books but in over 800 photographs taken in various portions of the interior.

We had scarce arrived in San Juan and presented our official letters to the Military Governor, General Henry, ere we were equipped with saddle animals and set forth on our first view of the interior. Certainly for us that first day's journey and those which succeeded it were days of discovery, though we had industriously read everything obtainable both in the Spanish and English languages relative to the island and though we were both thoroughly familiar through previous travel with the characteristics of many of



ROAD MAP
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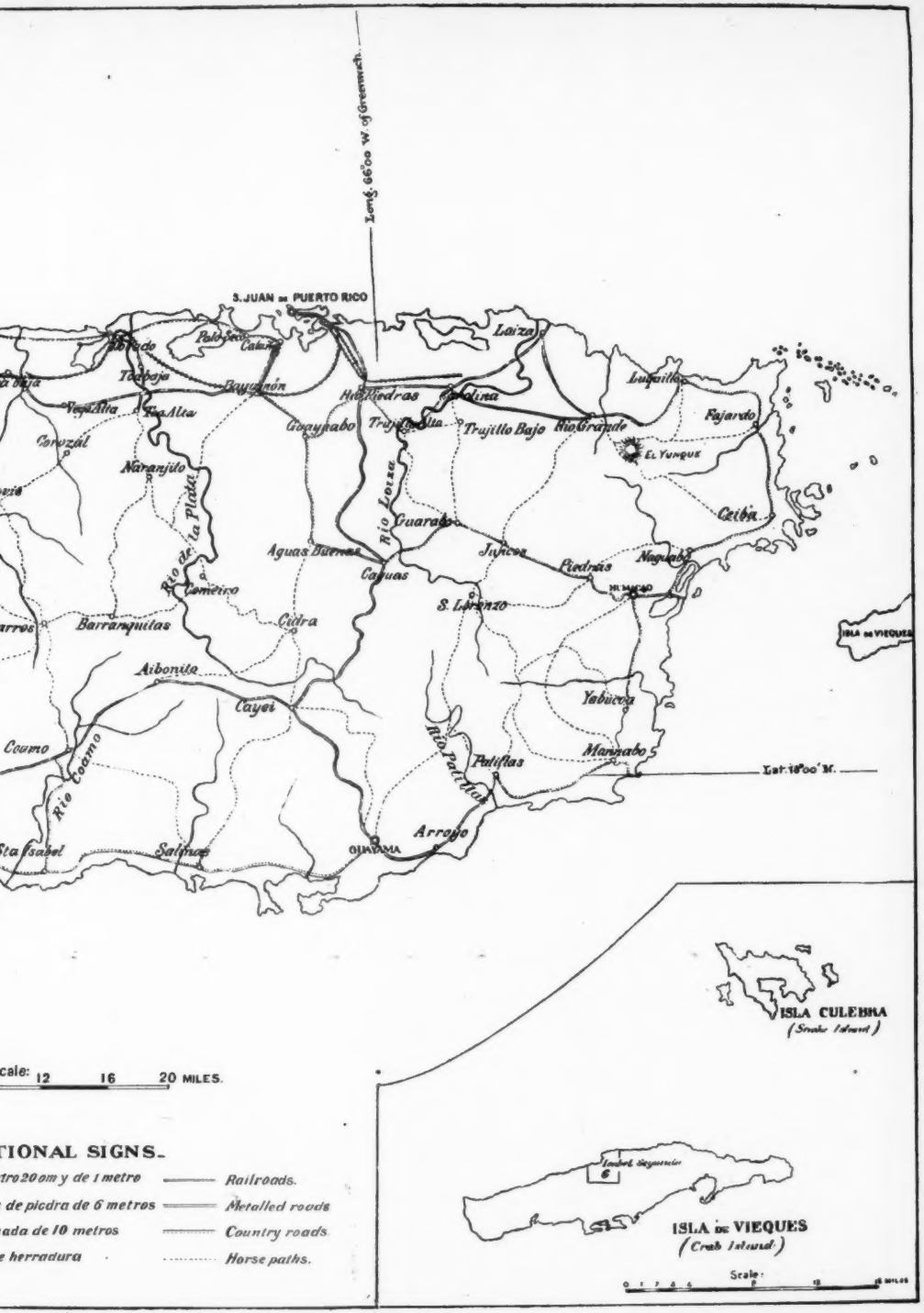
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Toa Alta
Toa Baja
Canovanas
Trujillo Alto
Trujillo Bajo
Rio Grande
El Yunque
Ceiba
Rio Loiza
Guaraho
Aguas Buenas
Caguas
Juncos
Piedras
Naguabo
Humacao
Rio de la Plata
Comerio
S. Lorenzo
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the West Indian islands and the neighboring Central American tropics. Nothing that has been written of Porto Rico conveys an adequate idea of the mildness of its semi-tropic climate, the fertility of its soil, the restful repose of its highly-cultivated scenery, and the liberality with which nature has showered her best gifts upon the latest and, I confidently believe, the most valuable addition to American territory.

Although situated in the Torrid Zone, between latitude 17° 54′ and 18° 30′ N. and longitude 65° 13′ and 67 ° 15′ W., the climate of Porto Rico is tempered by the first strength of the moisture-laden trade winds, because it is the eastern as well as the southernmost of the Great Antilles. Porto Rico is an island, the shores of which are bathed on the north by the waters of the Atlantic Ocean, on the south and east by those of the Caribbean Sea, and on the west by Mona Channel, which separates it from the island of Hayti. Its area is 3,670 square miles, or 1,200 square miles less than that of the State of Connecticut. Its average width is 35 miles and its length is—exclusive of Vieques and Culebra islands, which lie a few miles to its east, and of Mona Island, situated about 40 miles to its west—105 miles, or about the same length as Long Island, though it is twice as wide and nearly three times as great in area. Fourth in size of the Greater Antilles, it is roughly rectangular in form, its major axis lying almost exactly east and west, thus making it one of those few places which bear in nature an exact relation to our conventional ideas of north and south, and thus rendering it almost impossible for those of us who have difficulty in orienting ourselves to forget the cardinal points.

On November 16th, 1493, Columbus first landed on the west coast at what is now the port of Aguadilla, where he watered his ships at a spring from which a great volume still flows, and he is said to have named the island because of the richness of this port. The national Board on Geographic Names has officially decided that the name of this island is "Puerto Rico," because Puerto is the Spanish for port. There is no evidence, however, that *rich port* was the origin of the name of the island. The aboriginal inhabitants, who were of Arawak or Carib stock, were called by the early Spanish settlers "Borinquens," and the island was at first called "Borinquen." Later the Porto Ricans themselves took up the word Borinquen, which is to be found now printed upon numerous articles manufactured in the island as a trade-mark. It is the name common to the national air of Porto Rico, called the "Borinquena," and, as far as there is any direct evidence, the present name of the island is but a corruption of this

confused with the symbolism of the word Puerto Rico into Porto Rico. At all events, as this is the way in which all English-speaking merchants and geographers spell the word, this seems to be sufficient evidence for our retention for that form of spelling which now has the official sanction of Congressional legislation.

This island should be to us of the greatest historic interest because of its richness in sacred relics of the days of Spanish discovery and conquest. It is the only portion of our domain which is identified with the discoveries of Columbus and the early Spanish explorers. The very spring at which Columbus obtained water for his ships is now protected by walls of masonry and is a fountain from which the nearby inhabitants obtain their water supply. Ponce de Leon landed in the Bay of San Juan fifteen years after Columbus made his first landing at Aguadilla and founded near there in 1510 the village of Pueblo Viejo. Here the ruins of his first house are to be seen, though his first reputed residence has long been claimed to be in the city of San Juan in the building called "Casa Blanca," which is now used as one of the administrative buildings of our military government.

The early Borinquens were ruled by caciques like our North American Indians, and were not dissimilar to them in appearance, though more sallow, with long, coarse, reddish-black hair. At first the early Spanish settlers lived on amicable terms with them, but after one or two uprisings they were practically exterminated in 1815, and it is now said that scarce a trace of the original full blood remains.

The peasantry of the country, called "Gibaros," are of decidedly mixed stock, Spanish blood evidently predominating; yet they show not uncommonly traces of Barb and Malay ancestry in their physiognomy, and I have seen a number who must have had a large percentage of Borinquen blood in their veins. They were a little darker and more copper-colored than the average Porto Rican, rather shorter of stature, and their heads were adorned with long, curled locks of coarse hair, reddish brown in color. There was no evidence of negro nor of Spaniard in their faces, and such few as have knowledge of the ethnology of the island with whom I talked agreed that they were of aboriginal stock.

The population of Porto Rico is 953,200, of whom 59,390 are said to be negroes and the remainder of mixed blood. These bald figures scarcely state the facts. The negro is rarely seen on the island. One never meets the West India negro as he is encountered in Jamaica, Barbadoes and Hayti. All the people of black skin

who are encountered in Porto Rico have comparatively straight hair, and lack the broad nose and thick lips of the full-blooded negro. The negro problem is practically eliminated from the island of Porto Rico, and in this particular that island, like Cuba, differs from all others of the West Indies, where negroes predominate. Such black people as are encountered in Porto Rico are treated by their lighter-colored brethren as if their skins were of the same color. They intermarry and mix socially without any evidence of knowledge on the part of either that there is a difference in color between them.

The density of the population averages 225 per square mile, that of the eastern half of the island being greater than that of the western, and the average far in excess of that of any other of the Antilles. In fact, there are few portions of the United States where the density per square mile is so great. These figures of density do not give an adequate idea of the distribution of the population. The country region of Porto Rico is more completely inhabited and cultivated than almost any that I have seen. In this respect it compares favorably with our Mississippi Valley, Belgium and the Ganges Valley of India. From these it differs, however, in the fact that its population is not concentrated in cities of any size, but lives on small farms, either as private holdings or in peonage, and houses are to be seen scattered everywhere in the most inaccessible regions, on the steepest mountain sides, as in Switzerland, and in the depths of the most impassable ravines. The largest cities on the island are San Juan, with 32,048 inhabitants, and Ponce, with 27,952, the third in size being Mayaguez, on the west coast, with 15,187 inhabitants. In addition to these are dozens of smaller villages scattered everywhere throughout the interior and along the coast, at distances apart of fifteen to twenty-five miles, and containing from one thousand to six or seven thousand inhabitants. The remainder of the population is wholly agricultural and resides among the fields.

Let us now glance at the topography of this interesting island. From a scenic point of view it is one of the most beautiful of the tropic countries of the world. It is described by the Spaniards as "paradisiacal." They have always looked upon it as the most beautiful, fertile and delightful of their tropical possessions. In many places in the interior the scenery is superb, and is tempered with a melting loveliness of landscape by the numerous local rain-clouds, which give sufficient shadow to produce the softest effects.

This island is the easternmost of the Great Antilles. Its geology

and geographic origin have been best outlined by Mr. Robert Hill in his book on Cuba and the West Indies; and as I had the pleasure of officially studying the island in his company, I may be pardoned for here using some of his modes of expression in describing the physical history of the West Indies as a whole.

This group of islands is in no manner related geographically or geologically to the continents of South or North America. The great Andean cordillera, extending north and south, approximately in longitude 70°, would, if projected on the same axis northward, pass near New York. This fact, that South America is projected so far eastward that its western coast is in the same longitude as the eastern coast of North America, is rarely appreciated. The axis of the coast ranges, as well as of the main cordillera, of the Rocky Mountains in the western United States running in a general northwestward and southeastward direction, would, if projected through Mexico, pass into the ocean to the southwestward of that country in the neighborhood of Mazatlan in longitude 105°, and if projected still further south would pass hundreds of miles to the westward of South America in the Pacific Ocean. The general trend of these two great cordilleran systems is north and south, or approximately at right angles to the general trend of the great Antillean mountain ranges, which is almost due east and west. There is, therefore, no topographic, as there has been found to be no geologic, relation between the Antillean mountains and those of the cordillera of North and South America. On the other hand, they appear to be closely related to the mountains of Central America, particularly those in the neighborhood of Costa Rica, Honduras and of Southern Mexico. These mountains have an eastern and western trend, and are of the same geologic time as those of the Antilles.

The island of Porto Rico is but the summit of a mighty mountain, rising at the highest point to about 4,000 feet above sea-level at the north coast, and descending thence abruptly into one of the deepest-known valley-bottoms—the Brownson Deep, but comparatively few miles to the north and 24,000 feet beneath the surface of the sea, thus making the mountain summits 28,000 feet in height above their base on the sea-bottom. On the south the slopes are continued to the bottom of the Tanner Deep, 15,000 feet below the sea-surface and at a relatively greater distance from the island.

The topographic configuration of this island and its surrounding deeps is reproduced on its surface. There is practically no coast plain separating the steep slopes of the mountains from the depths

of the ocean. On the other hand, the slopes on the southern side of the island are more abrupt than those on its northern side. Parallel to the longest dimension of the island there is a central cordilleran system, which extends from the extreme northeastern end of the island near Fajardo to its southwestern extremity near Cabo Rojo. South of San Juan it is somewhat interrupted by a great, depressed drainage basin carrying the waters of the chief rivers of the island—the Rio Grande de Loisa and the Rio de la Plata, the headwaters of which have eroded the cordilleran summits backward to such an extent as to have forced the mass of the divide well toward the south coast in the neighborhood of Guayama. Eastward of this depressed area the main mountain range is known as the Sierra de Luquillo, which culminates near Fajardo in the highest peak upon the island, El Yunque, the elevation of which is stated by the Spanish authorities to be 1,520 metres, or about 4,940 feet; whereas its altitude, according to American authorities, is over 1,200 feet lower than this, or about 3,750 feet.

To the south of this depressed area, between Cayey and the coast near Guayama, the main range has the name of Sierra de Cayey, on which there are no summits of great altitude, the highest being about 3,000 feet above the sea, while the summits of the road-passes reach altitudes of 2,200 to 2,500 feet. West of Aibonito the central cordillera rises strongly, and is maintained unbroken to the extreme western end of the island, where the main spur reaches the coast in the neighborhood of Rincon, another pronounced spur disappearing in the sea to the south of Mayaguez. The second highest summit on the island is toward the western extremity of the central cordillera, immediately west of Adjuntas, and is called El Guilarte, the altitude of which is approximately 3,610 feet.

The summits of this cordilleran system are about one-third nearer the southern than the northern coast, the slopes falling away gradually into great, rugged mountain spurs to the northward and very abruptly to the low coastal plain to the southward. There is practically no coastal border on the north other than the alluvial playas, or back-coast border at the mouths of the rivers. These extend inland from two to three miles as fertile plains of triangular shape, the apex pointing up-stream and the base resting against the coast to either side of the river mouths. On the east and west the mountains reach the coast in much the same manner, falling abruptly into the sea between the river-beds, the only level land being in the stream-bottoms. On the south the main sierra

falls away so precipitately that in a distance of from three to five miles the greatest difference of elevation between the highest summits and sea-level is passed.

As seen from the south there is a relatively wider coast border in places, almost a true coastal plain, which is the extension by erosion eastward and westward of the playas at the mouths of the various rivers. In addition, owing to the prominence on this coast of a subsidiary foothill system of low limestone hills, which reach down in many places to the coast border, there is a secondary drainage system at right angles to the main system, which flows from the cordilleran summits, and which separates them from the coast hills. This secondary drainage system has been eroded back in such manner as to frequently almost eradicate the coast hills, and thus has extended the coast plains for from five to seven miles back to the foot of the abrupt escarpment in which the main Sierra rises.

The general aspect of the island, as seen from the ocean, is mountainous, but not strikingly so. As seen from any point in the interior on the trails crossing the island, the aspect is that of an exceedingly rugged and broken mountain country; yet it is pleasing because of its high state of cultivation and of the many picturesque, peasant and plantation buildings which are to be seen in all directions. I can scarcely recall any portion of the United States as highly eroded as is almost every portion of the interior of Porto Rico. Here and there among the mountains are small flats and pretty little valleys, the most level and attractive of which are those seen on the main military road, on the headwaters of the Plata and Loisa Rivers about Caguas and Cayey, and at Sabana Grande, Del Palmar, etc.

The coast-line of Porto Rico is comparatively free of indentations or irregularities, and, unlike that of Cuba, has practically no good bays furnishing safe harborage. The harbor of San Juan is anything but an ideal one, owing to the difficulty of crossing a very dangerous bar at its entrance. The inner harbor is capacious and safe. One of the best natural harbors on the island is that of Guanica, similar in many respects to the best in Cuba, and that at which General Miles landed with his Porto Rican expedition. This is an unimproved harbor, however, and is not an important commercial port. The other good harbors of the island, like it, are scarcely used by ocean ships, as they are at some distance from cities of importance. These are the Puerto Real of Cabo Rojo, on the southwest coast, and Jobos, the best of all, on the southern coast. The harbors of Ponce and Mayaguez, the two most important com-

mercial ports after San Juan, are both little more than open roadsteads.

Off the coast of Porto Rico are various islands belonging to its jurisdiction and now the territory of the United States. Most important among these are Vieques and Culebra, immediately to the eastward, the latter being almost half way from Porto Rico to Saint Thomas. So little has been known by us of these islands that it is interesting to observe that Culebra is as large as many of the more important of the other West Indian islands, having an area as great as the islands of Saint Thomas and San Juan and greater than that of many others of equal note. Vieques is at least twice the area of Culebra and is nearly as large as the island of Santa Cruz. The former of these is a comparatively barren and arid island of little agricultural value. On the other hand, Vieques is one of the most fertile spots in the West Indies, is highly cultivated, and produces wonderful crops, particularly of sugar cane. Between these and the main land of Porto Rico are several smaller islands of little moment. Just to the south of Ponce is a small island named Caja de Muertos, and close off the western coast is the island of Desecho; while still further west and about half way from Porto Rico to Hayti is the island of Mona, of little agricultural value, though covered with great deposits of valuable guano. In all there are about 20 islands of moderate size and many little rocks and reefs.

Owing to the comparative humidity of the climate, Porto Rico is unusually well watered. Flowing into the north coast are 12 rivers of considerable size; toward the west coast there are 4; toward the south 17, and toward the east 6. In addition to these there are over 1,300 smaller streams, which enter the ocean about the coastline, this great number being exclusive of the numerous large tributaries to the greater rivers which drain the interior. It will necessarily be realized that these rivers are of no great length; nor, as they drain relatively small areas, can they carry large volumes of water. Yet many of them, at low-water stage in the dry months of the winter, have water surfaces of from 100 to 200 feet in width near the coast, and the large portion of them are so deep as to be unfordable. This is particularly true of those rivers which flow to the north and west, those flowing to the south carrying much smaller volumes of water in the dry season and almost as much in the rainy season. There are no inland lakes on the island; but there are 8 small coastal lakes, the larger of which are those of Guanica, Arecibo and Cabo Rojo.

The geologic history of this island is simple. Below and border-

ing the ocean is a coastal series of recent and pleistocene age. It consists of horizontally-bedded strata of reef rock of coral origin separated by flat, alluvium playas, built up of sediment brought down by the various streams and aided in its accumulation by the encroachment of mangrove growth into the sea-water. Above this coastal series, and practically horizontally stratified beneath it, though at a greater altitude, are the older oceanic series of middle and later tertiary age. This consists chiefly of white limestone, produced in deep sea. This is of foraminiferal origin, and includes great masses of radiolarian earths. This oceanic series forms the larger part of the lower coast ridges on the north side of the island and of the coastal ranges and isolated summits on the southern border of the island. Above these in altitude and below them in geologic time is the third series, called by Hill the "Blue Mountain series." This is of latest cretaceous and eocene time, with, perhaps, some older basement rocks of volcanic origin, mixed and interspersed with streaks or masses of blue limestone of submarine origin. The limestone appears to have formed at the same time that volcanic action was most powerful, as it has volcanic rocks interstratified and mixed throughout its mass. This older series includes not only volcanic rocks but also their water-worn detritus. It is mostly porphyritic and gneissic, and in general appearance this mass of rocks is greyish-blue or slate-colored, which color has turned to brown and reddish tints, wherever it has been weathered, because of the iron contained in it.

Porto Rico is poor in minerals of economic value, both in quality and variety. A little gold is found as stream deposits in the foothills of the mountains southeast of San Juan, where a few inhabitants make a precarious living by washing the stream sands. These are of such richness as is called in California "pay dirt," by which is meant gravel which will earn wages and nothing more. Toward the extreme western end of the island, in the neighborhood of San Sebastian, are a few deposits of fairly good lignite, of doubtful commercial value because of the smallness of the quantity and the poorness of the quality. As a fuel it must rank far below the poorer grades of bituminous coal. Elsewhere are small deposits of phosphates, as guano, on Mona Island especially, and there are abundant deposits of green sand marl, rich in phosphates, which should in the future furnish sufficient fertilizers at least for the use of the island. Of iron there appears to be little of value; nor are there evidences of other minerals in merchantable quantities. A good brick clay is generally distributed throughout the island, and there is

abundance of good limestone from which to make high-grade mortar and perhaps cement. Several brickyards and limekilns are in operation in various portions of the island.

Climatically, the island may be divided into two distinct parts—the northern, which is humid, and the southern, which is semi-humid, bordering almost on arid. According to Professor Mark Harrington, ex-Chief of our National Weather Bureau, and recently in charge of the Division of Climatology of the West Indies, the rainfall is almost as diverse as in the United States. The southwestern portion of the island, near Cabo Rojo, was for one period of about three years without a drop of rainfall. At the opposite extremity of the island, the northeast end under El Yunque mountain, the average annual rainfall is 123 inches. At San Juan the average precipitation for 20 years has been 54 inches, considerably greater than at New York or Washington, where it averages about 45 inches. At Guayama, directly south of San Juan, not a drop of rain fell in 1893; yet in other years heavy tropic showers fall annually during the rainy season of from 6 to 8 inches in 24 hours. These are rainfalls of unprecedented amount in so short a period of time. Extreme rainfalls recorded in various parts of the island have been as great as an inch an hour for two to three hours. These storms occur suddenly during the rainy season all over the island, and even in the dry season on the north side of the island, at several intervals in each day. Everyone carries an umbrella and a mackintosh in San Juan, even in winter, and out of a bright sky, absolutely cloudless, there will suddenly fall, for ten to fifteen minutes, as heavy a shower as we would expect to encounter in the United States during the summer months.

The climatological transition from one side of the island to the other is clearly evidenced in the vegetation. On the north side the humidity of the climate is witnessed everywhere in the dense tropic verdure, the magnitude of streams but a few miles in length, and in the perpetual wet and muddy condition of the roads and trails. Immediately after crossing the main summit of the cordillera the grass on the southern slope is observed to be yellow and dry as that of Texas or the western Kansas plains. In many places the vegetation is entirely similar in every aspect to that of Western Texas and of Arizona; the hillsides are covered with dry grass, and acacia, yucca, cactus and other arid plants abound, none of which are to be found on the north coast. One must not reason, however, from this that it is a truly arid country. Its most arid aspect is witnessed only during the dry season. During the summer, or rainy season,

there is sufficient precipitation, excepting in a few localities and in unusual seasons, to render it possible to cultivate many valuable crops. Only in a few scattered localities is it necessary to irrigate, and then only the sugar cane. West of Ponce, and between that city and Mayaguez, is practically the only portion of the island so arid that one finds great fields of our Indian corn, of beans, pine-apples and similar semi-arid tropic crops.

The great relative humidity of the north coast of Porto Rico, as well as the remarkably uniform and mild temperature of the entire island, are due chiefly to the trade-winds, which blow with great force from the northeast all the year round. These winds temper the climate and, striking against the high summits, are condensed and deposit their moisture. Passing over these they are more dry, and the farther to the westward they advance through the Caribbean Sea, toward Central America, the less humid and the warmer are these trade-winds. It will thus be realized that because of its vantage point as the extreme eastern of the Great Antilles, Porto Rico derives a climatic benefit from these winds which is possessed by none other of those islands. It is more moist and, therefore, more fertile than Santo Domingo, and still more so than Cuba, and its temperature is less high and more uniform than that of either of the latter islands.

The average daily temperature on the island, taken year in and year out, is 80 degrees, and this is ameliorated by the cooling north breeze which prevails even in the hottest days. The maximum heat ever recorded, and this only on three occasions, has been 99 degrees, and the minimum 70 degrees. In the hottest weather the thermometer frequently records 90 degrees, but rarely more, and falls as low as 75 to 80 degrees at night. During the entire winter, or dry season, the thermometer rarely records more than 75 degrees, nor does it fall much below 65 degrees, except in unusual days. The hottest months are from June to September, and the coolest from December to February. The wettest are from September to November, and the dryest from January to March. The mean monthly temperature of Porto Rico hardly varies 10 degrees throughout the year, the extreme recorded limits being 40 degrees instead of over 100 degrees as in New York. It is a rare thing when one cannot sleep comfortably at night—an occurrence not so infrequent in our own country.

The soil of Porto Rico is of remarkable fertility, due to its origin in the disintegration of coral limestone and the basic igneous rocks. Where coffee is cultivated the soil is a dense red, greasy clay, the

result of decomposition of the underlying volcanic rock, and fertilized by a thick covering of black vegetable mould. In all the river valleys which border the island at frequent intervals, sugar is practically the sole agricultural product. In the lower foot hills, which rise gently from the river bottoms and the coast border, there is a dense growth on the moist or northern coast of guinea grass, which furnishes excellent forage, and on the southern or more arid coast of other varieties of grass, which luxuriate naturally and furnish great fields in which are pastured herds of cattle.

In addition to the sugar grown on the coast plains, tobacco is raised in great quantities on the lower northern slopes, and is of the first quality. From it a grade of cigars and cigarettes is made equal almost to the best exported from Havana, and containing much of the bouquet for which Pinar del Rio tobacco is noted. It is not an unusual sight to see hundreds of acres of the steepest mountain slopes intensely cultivated with tobacco, not a weed in sight, and groups of laborers, ten to twenty in a group, clinging like ants to the hillsides, hoeing or gathering the product. A variety of cotton of long staple and fine fibre grows wild and on bushes as large as peach trees—so large, in fact, that it took some time for me to realize that these were truly cotton plants and not some allied tree. Yet, for some unaccountable reason, the Spaniards have never encouraged the cultivation of cotton, and little or none is grown. Porto Rico is also noted for a variety of upland or mountain rice of excellent flavor, but rather darker in color than those varieties which are in favor in European markets. Yet rice is but little cultivated at present, though at one time great quantities were produced. The chief reason for the decadence of its cultivation has been its discouragement by the Spanish Government in order that the rice of Spain might be exported to Porto Rico.

As I have already intimated, coffee is the staple product of the island, grown universally above an altitude of twelve hundred feet; and as it is more luxuriant, the crop larger and the quality better the higher up it is grown, the most rugged mountain summits are planted with this valuable bush. As the coffee plant is delicate and requires to be protected from the sun, it is always grown under the shade of some tree, as the guava, guama or banana.

In addition to the above the interior of the island produces all the vegetables of the tropic and temperate zones, including tomatoes, potatoes, yams, peas, sweet potatoes, etc. These are displayed each morning in the markets, as are also all the tropical fruits, including oranges of many varieties and of good flavor, bananas,

pineapples, the latter especially in the southwestern portion of the island, aguacate, guava, limes, etc.

The flora is varied and beautiful; great masses of marguerites, sweet peas and single poppies of large flower and brilliant coloring illuminate the slopes, as do the white and yellow daisy the fields of our own country. Many of the more beautiful of our hothouse or cultivated flowers grow wild; among them hydrangeas, hollyhocks, numerous brilliant-colored begonias and the coleus. Much of the coloring in the foliage, however, is produced by colored leaves, not only of plants but of trees, which give the effect of flowers. The most brilliant of these is the poinsettia, a gorgeous cardinal leaf several inches in length, and the flamboya, a tree of the acacia variety, which is densely covered with small flowers similar in general appearance to the locust, but of radiant vermilion color; and also the clematis, hibiscus and magnolia. Ferns of all varieties, sizes and shapes, up to those of the fern tree, make a literal jungle of the more shady slopes. Beautiful mosses and numerous orchids abound on the rocks and as parasites upon the trees.

Among the indigenous trees, a few of which still exist in the forest, but scarcely in merchantable quantities, are ebony, mahogany, lignum-vitae, ironwood, rosewood and Spanish cedar. The latter is used extensively in making cigar boxes, and also in trimming the interior of such private residences as can afford the expenditure of such rare wood. Mahogany is one of the most abundantly used of woods, being employed for all the more common structures, as fence-posts, sills, uprights, scantling and roof timbers for dwelling-houses, and the bodies, wheels and other parts of carts. There are twenty-eight varieties of medicinal plants, including about twelve which furnish condiments, twelve which furnish dyes and tanning materials, and eight resinous trees. These include gum copal, guaiacum and similar products, which are extensively exported.

Porto Rico is exceedingly poor in indigenous fauna, not only of animals, but of birds and fishes. The largest native quadrupeds are an agouti and an armadillo, both of which are so rare as to be practically extinct. Next in size and most abundant in numbers are the common rat, found chiefly about cities and wharves; also some ground squirrels and similar animals. There are scarcely any reptiles, and none of poisonous variety. Food fishes are exceedingly rare in the waters of the interior and in those surrounding the island. Small song-birds of brilliant plumage are fairly numerous, but large birds of any kind, including parrots, are comparatively rare. Even poisonous insects are relatively less numerous and

troublesome than in many other tropic countries, although there are a sufficient number of these to torment the unacclimated stranger.

The cattle of Porto Rico are a most interesting sight to one acquainted with the dwarfed animals which are found on other West Indian islands, in Central America and our southern States. The Porto Rican cattle are of Andalusian extraction; are large, heavy animals, with great, wide-spreading horns, and with proper care and with discrimination in the selection of those to be slaughtered they will furnish one of the most valuable products of the island. At present quantities of them are exported to neighboring islands. On the other hand, the horses and mules of Porto Rico are as disproportionately small as the cattle are large. They are not much larger than Shetland ponies, yet they are so sure-footed and so powerful that they bear burdens and make journeys which would put to shame many of the larger animals of which we are so proud. The average burden for the laden pack mule in the western United States is from 200 to 300 pounds, yet it is a common sight to see trains of these little ponies and mules laden with 200 pounds of coffee, which they carry with apparent ease over the most rugged trails that it has been my fortune to encounter. Harnessed to the little landaus which are popularly used in the cities of Porto Rico and on the main military road crossing the island from San Juan to Ponce, these tough little beasts never descend to a gait slower than a fast trot, and rarely take one slower than a gallop. Thus they race with the mail and passenger coaches up and down hill over the finely macadamized military road, covering regularly the distance of eighty miles from San Juan to Ponce in twenty-one hours, including numerous stops for relays and for meals.

This is essentially the land of the small farmer; it is the only one of the West Indian Islands where agriculture is so diversified that sufficient food is produced for the sustenance of the inhabitants. There are about 1,100 of the larger sugar, coffee and tobacco plantations, but the great proportion of the island is cultivated in individual holdings, of which there are about 21,000. Of these, 13,000 are devoted to the cultivation of small fruits and vegetables, and about 4,000 each are devoted to miscellaneous crops, and to fruits and coffee.

Next after Spain and Cuba the United States ranks about equal with England and Germany in commerce with the island of Porto Rico. The exports to Spain in 1895 were about $5,800,000, and to the United States $1,800,000. The imports from Spain in the

same year were $8,600,000, and from the United States $1,500,000. These are the figures published in Consular Reports and in the Commercial Statistics published in the island of Porto Rico. There is no evidence of the above extensive importations from the United States to be found in an inspection of the wholesale or retail establishments of the island other than in the large quantities of corrugated iron used for roofing, of pine lumber and of kerosene oil. All of the dress goods, notions, and smaller manufactured articles sold in the retail stores in the cities are of Spanish or German manufacture. I was especially discouraged upon purchasing an attractive olla, or water jar, of particularly characteristic Latin-American design, to find a printed label on its under side upon which were the words "Made in Germany." Yet in those words is the key to German supremacy in the small mercantile trade of Spanish America. Our manufacturers insist on sending to such countries a type of goods and products which they are accustomed to make and sell in our country, and seem determined to force these upon the inhabitants of another clime. The German invariably finds out what the people with whom he has to deal use and desire, and he makes goods of the material and pattern to which they are accustomed.

The principal articles of export are coffee, $8,790,000; sugar, $3,750,000; tobacco, $645,000; honey, $520,000. The chief articles of import are rice from Spain, $2,180,000; fish, in the form of codfish from Nova Scotia, the chief food article of the gibaros, $1,890,000; meat and lard, $200,000; and flour, $980,000.

Transportation on the island is of the most unsatisfactory kind. There are about 140 miles of French railroad, of narrow gauge, cheap construction and slow operation. This is a portion of the system of railways planned to girdle the island, less than half of which has yet been constructed. There can scarcely be said to exist any roads upon the island outside of the military roads, that feature of the transportation having been well cared for, while the comfort and needs of the inhabitants have been entirely neglected. The roads are divided into three classes. Of the first class, or military roads, there are 285 miles, of which 80 miles cross the island from San Juan to Ponce, and the remainder are scattered about the coast. These are of the very best class of macadam construction. The road surface is kept in good repair under the American administration, following the Spanish system, by road laborers, each of whom has but a mile or less of highway to care

for. All streams are passed on substantial masonry or iron bridges and culverts, and the grades are of the best.

In addition there are said to be about 550 miles of second-class or cart roads. None of these are of such quality as would be considered passable in our country. They are dirt roads, originally fairly well constructed, but never repaired. As a result, owing to the great amount of moisture, they have been so cut up as to be practically impassable even to two-wheeled bullock carts, much less by four-wheeled vehicles. It is not an unusual sight to see a coffee-planter sending less than a quarter of a ton on one of these carts as a load, and hauled by at least ten to fourteen bullocks, which are scarcely able to drag it through the axle-deep mud. Finally, trails passable only by the sure-footed native ponies ramify everywhere throughout the island, climbing the most precipitous summits or descending into the deepest ravines and leading to all fields and residences. Over these the bulk of the trade of the island is carried by pack animals. Communication is well established throughout the island by a number of postal routes, with post offices now managed as branches of the Washington City post office in all the cities of 1,000 inhabitants and upward, and there are between 470 and 500 miles of telegraph line reaching also to all principal cities and operated under Government control.

The gibaros, or peasantry of Porto Rico, have been aptly described as like the peasantry of Ireland—proverbial for their hospitality, light-hearted and happy, and yet ready to fight on the slightest provocation. They swing all day in the shade of a banana or orange tree in their hammocks, smoking cigarettes or cigars, picking the *tiple* or small native guitar to time scraped with a piece of wire on the roughened surface of a calabash; this instrument, the guitarra, being the national instrument, and found in almost every house on the island. The plantain or palm grove which shades the house, the coffee bushes and tobacco plants, all of which grow almost without cultivation, afford sufficient though frugal sustenance. A few gamecocks and a couple of pigs tethered by strings, a machete and a few earthen pots, form the extent of their movable property. When it is necessary to procure anything else they mount their little ponies, straddle the panier baskets laden with coffee and plantains, and with their machetes in their hands and dressed in a white cotton shirt and pantaloons, not dissimilar to pajamas, they proceed to town for the purpose of trade.

Of the cities San Juan is the only one which is fortified. Its chief fortifications consist of Morro Castle, commenced in 1534 and

standing to-day much as when finally completed in 1584. It is a magnificent and picturesque pile of masonry, descending from the extreme height of the Island of San Juan to the water edge, and against which the ocean waves incessantly thunder. In addition and at a little distance is the fortress of San Cristóbal, built in 1751, a massive structure standing well to the rear of the city in such manner as to defend the city walls, of masonry like the Morro, and even more brilliantly colored with the crude Moorish pigments which lend such splendid effects to the remaining buildings in the city.

Ponce is essentially the commercial city of Porto Rico. It is one of the principal shipping ports for sugar and coffee, and the Playa, which is the seaport of Ponce and situated about three miles from it, though the main road between the two is well built up, is by far the busiest shipping port.

Mayaguez, the third city in importance, is essentially the residential city. It has a fair business both with the interior and through export and import trade, but for its private residences it is especially notable. Like Ponce, Mayaguez is a couple of miles back from the ocean front, with which it is connected by a well-built thoroughfare leading to the playa or port, a small commercial suburb of great activity.

The home life of the Americans now residing in Mayaguez is most agreeable. The city is clean, well paved, its sanitation is the best on the island, as well as its water supply. The private houses of the residents are beautifully constructed, and the better class of people are not so absorbed in business as to reside over their stores, as they do in San Juan and Ponce, but have comfortable homes separate from the business quarter. They have treated the American officers and their wives more cordially than elsewhere, and there is a delightful social intercourse between the two, which makes Mayaguez, if for no other reason, the most attractive city for Americans. For various other reasons, however, Mayaguez impressed me as one of the most pleasing tropical cities I have seen and one which is destined in the future to be a great winter resort for our people.

San Juan is far less attractive because of the great rainfall, which renders it almost impossible to go out in the streets without certainty of being wetted before one can return. Ponce, on the other hand, is too busy and too much absorbed in commercial affairs to give promise of being one of the future residential cities. Scattered elsewhere throughout the interior of Porto Rico are numerous

cities of even as few inhabitants as 1,000 persons which will frequently put to shame our own villages of equal proportions. They are generally fairly well paved with cobblestones or macadam. They are provided with delightful public squares or plazas. They have good sikewalks and are lighted with lamps or by electricity. The better class live in substantial masonry residences, not infrequently in the second floors above the business houses. This, however, is largely for sanitary reasons, as owing to the perpetual moisture of the ground, all structures, even those of the poorest peasantry, are raised somewhat above the ground surface, and wherever practicable they are supported on pillars allowing passage for air beneath the living rooms.

In general the sanitary condition of the cities of Porto Rico is far worse than it should be, yet not as bad as that of the cities of Cuba and of many other tropical regions and of many of our own southern towns. In no city, even the largest, is there an underground system of sewage. There is always excellent surface drainage, due to the steep grades found everywhere. The streets are now, especially under American régime, fairly clean, and the garbage is removed, though the liquid refuse of the house is always discharged into cesspools in the courtyards, which in the past have not been cleaned as frequently as they should be. The water supply is about equally divided between that obtained from rainfall, in which case it is so often replenished by the clouds as to be fairly pure and wholesome, and that obtained from running streams. The stream water is most dangerous to the stranger and should never be taken without boiling. All of the water consumed on the island is filtered through porous earthern jars, which give it a clear and limpid appearance, even though it may be contaminated from bad sewage or other causes.

The city of San Juan is located on a small island but three miles in length, its maximum width being scarcely a mile. It is compactly built, laid out on a rectangular system, six streets running east and west and seven north and south. The streets are narrow and the houses two and three stories in height and all of substantial masonry, covered with a smooth surface of plaster and most picturesquely decorated in flat tints of white, brown, yellow, blue, purple, green, pink and vermilion. The result is oriental and picturesque in the extreme. Never has it been my good fortune to gaze upon a more inspiring and artistic spectacle than that witnessed in the early morning as our ship crossed the bar to San Juan harbor. On the west rose precipitously from the water's edge the

massive sea wall, crowned by the ponderous battlements of Morro Castle. In front and to the right opened out the broad expanse of the inner harbor dotted with picturesque shipping, set in a background of low, green palm-covered shores and distant blue hills. Between the two and rapidly unfolding as we passed the point of the Morro, there rose on the left tier above tier to the highest summit of the little island, one building apparently on top of the other, until the city was disclosed in a series of many-colored walls and terraces, crowned by the frowning heights of San Cristóbal.

PHYSIOGRAPHIC NOTES.

BY

RALPH S. TARR.

THE SHAPE OF THE EARTH.—When William Lowthian Green published his *Vestiges of the Molten Globe*, it attracted practically no attention, and nearly all who gave it any consideration looked upon it as a vague speculation. In England and America his theory has, until within the last year or two, been neglected; but once people began to study it with seriousness, it has been interesting to watch the respectful attention which his theory has received. Gregory's paper, in the *Geographical Journal*, has already been abstracted in these notes. (See Bull. Amer. Geographical Society, Vol. XXVI, 1899, p. 259.)

Now Professor Emerson presents a consideration of the Tetrahedral theory in his address as President of the Geological Society of America. (*Bulletin Geo. Soc.*, Vol. XI, 1900, pp. 61–106.) As a whole, Emerson seems to favor the hypothesis proposed by Green. He considers with Green that this tetrahedral theory accounts for the triangular shape of the continents pointing southward, and of the oceans pointing northward, and that it also accounts for the fact that in general the land is antipodal to the water.

One of the difficulties which Green encounters in his attempt to explain the larger earth-forms is the fact that the southern continents are not in exactly the position that they should be upon the theory. Moreover, between the southern and northern continents is a zone of depression and of mountain-folding, represented by the West Indies, the Gulf of Mexico, and the zone of disturbance in the neighborhood of the Mediterranean and, east of this, in the neighborhood of Southern Asia. This "zone of intercontinental seas" serves Emerson with an opportunity for considerable discussion. Green accounts for it as being a plane of weakness along which a shifting took place, as along the twinning plane of a crystal, with the result of throwing the southern continents out of line. Emerson suggests the alternate speculation, that when formed the zone of fracture was in reality the equatorial zone In the course of further cooling of the globe the equator and pole were shifted to their present position.

It is impossible in a brief space properly to summarise Emerson's paper, but any one interested in speculation concerning the origin of earth-form will find here much food for thought.

Ancient Glaciers in the Sierra Costa of California.— Little by little we are gaining information concerning the form of glaciation in the mountains of the West. A recent paper by Hershey (*Journal of Geology*, VIII, 1900, pp. 48–57) describes the evidences of individual glaciers among the Sierra Costa mountains of northwestern California. Aside from his description of the evidences of glaciation, there are one or two points worthy of note. He finds that the valleys which were occupied by the ice show distinct signs of their occupation in several ways. The talus material has been removed from the valley sides. The valleys have been smoothed and given rounded slopes, with gently rounded floors, thus becoming U-shaped. In the course of this glacial erosion many of the side ravines have been destroyed, partly by grinding back, partly by deposit in the valleys.

At first Hershey thought he had found signs of two glacial epochs, one much older than the other; but further study has led him to the conclusion that this evidence is not valid. The deposits near the end of the glaciated valleys are slightly older in appearance than those near the heads of the valleys. It is a question that has often arisen in my own mind whether a considerable amount of the so-called ancient drift of the first glacial epoch is not in reality material of residual decay pushed to the edge of the ice during its earliest advance.

In Hershey's opinion an elevation of three thousand feet would be sufficient at present to cause reduplication of the ancient glaciers, and he seems inclined towards the belief that this is the only explanation of the glaciation of this region.

Evidence of Glacial Erosion of Loch Lochy, Scotland.— While for a number of years glacial geologists have been rather averse to the admission that glaciers have done distinctly important work in erosion, it is interesting to note that there seems now a tendency in many directions to accept the evidence—which is very clear—that the glaciers have eroded certain surfaces very perceptibly. Blanford (*Quarterly Journal, Geological Society*, LVI, 1900, pp. 108–204) calls attention to the evidence of glacial erosion which he has noticed in Loch Lochy. The valley side is a sloping plain, and the tributary valleys to this, which are quite pronounced higher up on

the hill-side, are entirely absent near the base of the hill-slope. Blanford's explanation of this condition is that the passage of the ice through the valley planed back the hill-slope so far that the tributary valleys were erased near their lower ends. Something of this same sort may also be noticed in the longitudinal valleys of central New York, as, for instance, the valley of Lake Cayuga; but here, while lateral erosion has doubtless been one cause, valley-deepening has certainly been an even more important cause for the peculiarity which Blanford describes. (See Tarr, *Bull. Geol. Society Amer.*, V, 1894, p. 339.)

Another point of importance in Blanford's brief paper is his consideration of the evidence furnished by the small lateral gullies which have been eroded in the glacial deposit that veneers the hill-side. These, he points out, are entirely post-glacial. They are quite pronounced. And it would be a simple matter for careful study to use their present rate of erosion in making an estimate of the time since the ice withdrew. Blanford is impressed by the fact that these gullies cannot have required a very long time for their formation. His own conclusion is that which many others have adopted from evidence elsewhere—that an estimate of 10,000 years is probably nearer the truth than the longer estimates for post-glacial time of some of the workers.

It is to be noted that while an estimate of the present rate of erosion, as proposed by Blanford, will, of course, be of value, it could not be taken as an exact basis for a conclusion as to the number of years since the glacial period, because there are modifying factors. During the greater part of the time since the glacial period these hill-slopes have had the protection of vegetation, now removed. Moreover, the amount of water supplied by the melting of the ice and snow, and possibly even by heavier rainfall, may have been much greater at an earlier time than now.

NOTES ON CLIMATOLOGY.

BY

ROBERT DEC. WARD.

THE CLIMATE OF SAN FRANCISCO.—San Francisco has, in some respects, one of the most interesting climates in the United States, the most striking feature being the delay of the maximum monthly mean temperature beyond the middle of the summer into September. This results from the fact that the city lies at an opening in the coast range of mountains, through which there is a strong indraft of air from the Pacific towards the interior valley, while the latter is most warmed under the summer sun. This strong onshore wind prevents the temperature at San Francisco from reaching a maximum in midsummer, as is usually the case. The maximum monthly mean temperature is displaced into September, when the interior valley is less warmed, and when, therefore, the onshore wind at San Francisco is less strong, and its cooling effect less marked. *The climate of San Francisco* has been made the subject of a recent *Bulletin* (No. 28) of the United States Weather Bureau, prepared by A. G. McAdie, Local Forecast Official at San Francisco, and G. H. Willson. The rainfall data used in this discussion go back to 1849, while the temperature and other records begin in 1871. The Bulletin is chiefly made up of tabular matter, the discussion being limited to three pages out of 25. One could have wished for something in the way of a description of the seasonal weather types which go to make up the climate of San Francisco. Tables of climatic data, while of great importance, are dry and unattractive, and really convey little meaning to the average reader. The mean annual temperature of San Francisco is 56.2°. The warmest month is September, with 60.9°; the coldest month is January, with 50.1°. The highest temperature on record is 100°, which was noted on June 29, 1891, and the lowest was 29°, on January 15, 1888. The annual rainfall is 23 inches. July and August are practically without rain, while December and January together have nearly 10 inches. The crop yield is largest when, other things being equal, rain falls generously in March and April.

RELATIVE HUMIDITY AS AN ELEMENT OF CLIMATE.—The importance of relative humidity in determining, together with temper-

ature, the degree of comfort or discomfort that is felt under different weather conditions, is a matter that is coming to be more and more recognized and discussed. Lancaster has recently published a paper in this connection, entitled *De la Manière d'utiliser les Observations hygrométriques* (Rapport lu au Vme Congrès International d'Hydrologie, de Climatologie et de Géologie médicales à Liège, 1898). As a result of a long series of personal observations made in Belgium, the author concludes that the heat there becomes very oppressive when, the temperature being about 86° F., the relative humidity reaches 40%. For lower temperatures the heat becomes very oppressive when the relative humidity rises above the following percentages for the given temperatures:

Temperature.....	84°	82.5°	80.5°–77°	75°–73.5°	71.5°–70°
Relative Humidity..	45%	50%	65%	70%	75%

In the case of Vivi, in the Congo Free State, the mean relative humidity with a temperature of 86° is 59%. In Belgium, the relative humidity, with that same temperature, averages 36%, and personal experience shows that if the relative humidity in Belgium rises to 40%, with a temperature of 86°, the heat is almost unbearable. This sort of investigation can readily be undertaken by any one, and offers opportunity for obtaining most interesting results.

KÖPPEN'S KLIMALEHRE.—One of the most useful little publications in the field of climatology is *Klimalehre*, by Dr. W. Köppen, of the Deutsche Seewarte, in Hamburg. (Leipzig, Sammlung Göschen, 1899. Small 8vo, pp. 122. Price 80 pfgs.) Hann's *Handbuch der Klimatologie*, a second edition of which, in three volumes, was issued in 1897, has been, since the publication of the first edition in 1883, and will for years remain, the standard publication on climatology. But Köppen's little book, with its small size and low price, will certainly make a place for itself. It sets forth the principles of climatology clearly and systematically, and will serve admirably for those who, having a good general knowledge of meteorology, wish to learn something of climatology as well. While all the chapters in the book are models of what a competent author can do in a very limited space, the last chapter is perhaps the best of all in this respect. In this chapter of 17 pages we are given an admirable discussion of the five climatic zones, the characteristics of each of these zones, and a suggestive, though necessarily very short, account of the relation of the zones to civilization.

Loss of Life by Lightning in 1899.—Thunderstorms are one of the characteristic climatic phenomena of the United States, and the damage that is done by lightning is therefore a perfectly legitimate subject for comment in these Notes. During the year 1899, 562 persons were killed outright by lightning in the United States, or else suffered injuries which resulted in death, as reported by Professor A. J. Henry in the *Monthly Weather Review* for March. The number of persons who received injuries varying in severity from slight physical shock to painful burns was 820. This loss of human life by lightning during the past year was greater than for any preceding year for which statistics have been collected. The greatest number of fatalities (45%) occurred in the open; the next greatest number (34%) occurred in houses; 11% occurred under trees, and 9% in barns.

The Effect of Seasons upon Railroad Building in Ecuador.—The Government of Ecuador has lately granted a concession for the building of a railroad from Guayaquil to Quito, the capital of Ecuador. The latter city has hitherto been reached only by mule or horseback. There are many difficulties of construction to be encountered, but the building of the railroad is also much delayed by the rainy season. According to "El Progreso de Quito," as quoted in the *Bulletin of the Bureau of American Republics* for April, work on this road will not be carried on actively during the rainy season, owing to the fact that the majority of native laborers object to engaging in outdoor work during the winter, when they are exposed to torrential rains, and when, furthermore, the low temperatures in the Cordilleras are keenly felt.

The Weather and the Price of Wheat.—Mr. R. C. Mossman, of Edinburgh, has recently published a paper on *The Price of Wheat at Haddington from 1627 to 1897*, which was read before the Scottish Society of Economists. The investigation is an interesting one, and brings to light some rather striking facts. The most extraordinary prices were in 1800 and 1812, heavy rains and a low August temperature being the chief causes in the first case. The high price in 1812 was due to a deficiency of the crop of 1811, without the means of obtaining any wheat from abroad. In 1879 there was a rise in price, which was the result of the extraordinary severity of the weather; and in 1891 the rise was due to a severe rye famine in Russia, and to the supply in the two preceding years being inadequate to meet the demand.

MR. H. L. BRIDGMAN ON PEARY'S WORK.

Secretary Herbert L. Bridgman, of the Peary Arctic Club, addressed the Society, at its first meeting in Mendelssohn Hall, on Tuesday, April 17, on "Peary's Work in the Arctic in 1898–99 and 1900." Mr. Bridgman, who was in command of the *Diana* Expedition of 1899, spoke without notes and showed many lantern illustrations, some from photographs by Mr. Peary, and developed from plates sent home by him, and others from the camera of Prof. William Libbey, foreign corresponding secretary of the Society, and leader of the Princeton Scientific party on the *Diana*. Many of Mr. Peary's views were of his new discoveries in Grinnell Land and illustrated topography and localities never before seen by man. The lecture was of a familiar and informal character, more a personal narrative than a scientific or geographic paper, and may be satisfactorily summarized in the following unpublished report of Mr. Bridgman to the Peary Club on his return from the North in September, 1899:

The Club's chartered steamer *Diana*, Capt. S. W. Bartlett, left St. Johns, N. F., July 15, arriving at Sydney, C. B., July 17. Coal, the generous gift of the Dominion Coal Company, and provisions having been taken on board, the steamer left Sydney for the North at 4.30 Friday, July 21, one day later than the date appointed by Mr. Peary in his memorandum from Etah, Aug. 12, 1898. Our northern course was almost a duplicate of his letter. Letters were mailed at Domino Run, Labrador, Tuesday, July 25; the Labrador ice-sheet of seventy-five or eighty miles traversed during that night and the following day required about fourteen hours, the Greenland coast was sighted near Sukkertoppen, Friday, July 28, and at 8 on the evening of the 30th anchor was dropped at Disco.

An immediate call on Gov. Olsen, to whom our credentials from the Department of State were presented, disclosed the fact that no news had been received of Peary or the *Windward*. Gov. and Mrs. Olsen, with their two sons, returned our call the next morning; and in ten minutes after they had left the *Diana* she was under way via the Waigat for the North.

Upernavik was reached at 7 Tuesday afternoon, Aug. 1, and having exchanged official courtesies with Gov. Krauth, who had no news of Peary or the *Windward*, and delivering to him parcels from Gov. Olsen, with less than two hours' detention, we were again on our course. Melville Bay was crossed in twenty and one-half hours, the shortest time on record, and Cape York and the southernmost native settlement reached at 9 Thursday morning, Aug. 3. Here we gathered from the natives that the *Windward* had wintered somewhere on the Grinnell Land coast, and at the next settlement, Saunders Island, fifty miles north, reached at 9 that evening, a native delivered the following note, in pencil, on a half sheet of note-paper, enclosed in a pasteboard envelope fifteen inches long and two wide:

Captain, Peary Auxiliary Steamer:

"You will find a note in pole on top of Littleton Island. April , 1899. PEARY."

The natives also made us understand that Peary had met with an accident to his

feet, and that they had subsequently seen him walking and getting about as usual. Full speed was rung for Littleton Island and ten natives were taken on board for any service—hunting or other—which they might render. As we were passing the entrance of Foulke Fiord, Friday, Aug. 4, at 3 P. M., one of the natives on the bridge made the officer understand that there were people and possibly letters at Etah, six miles up the fiord. Changing our course and blowing the *Diana's* whistle, we soon had the satisfaction of taking from the Peary dory Matt Henson, who delivered the following letter to Capt. Bartlett:

WINDWARD, April 28, 1899.

DEAR SAM:

Just a line to let you know where we are and that all hands are quite well. You will likely arrive at Etah before we get down. So I chance this by some Eskimos going down.

We were stopped here on the 18th of August, frozen in on the 23rd under Cape D'Urville, the south head of Allman Bay, about fifty miles north of Cape Sabine. The whole basin and channel were blocked all the season with heavy ice. As there is no probability of any one going down over the ice cap, I should not imagine there will be much need of your visiting Bowdoin Bay very early. Mr. Peary went north to Fort Conger on the 18th, and will not likely return before the middle of June, so I have no idea what his plans will be for next summer, but we will be in no condition for going north, as we shall be short of coal. Will have about ten days' steaming. I have no idea what time this ice will break up, but fear it won't until about from the first to the fifteenth of August. It seems to be a regular eddy in here, perfectly still, and we have had no wind or snow since leaving you last August, but very intense frost. I hope you will be able to keep well up to the down on this west side. Yours affectionately, JOHN BARTLETT.

P. S.—The Fram wintered just inside Cape Sabine.

Anchoring at Etah for the night, the Littleton Island post office and mail were brought on board the next morning, and Mr. Peary's letter "received and contents noted." (This letter was printed in BULLETIN No. 4, 1899, pp. 380–381.)

Saturday was occupied in landing the Robert Stein party and effects at Payer Harbor, near Cape Sabine. Soon after leaving Payer Harbor to return to Etah a ship was made out to the northwest, and in the hope, confirmed by Henson's assertion, that the *Windward* was coming out of her winter quarters we steamed for several hours through loose ice toward her, reaching the latitude approximately of 79° 10′. Finally, however, the stranger was definitely made out to be the *Fram*, whereupon the *Diana* returned to Etah, where she remained Sunday and, windbound, Monday.

Forty walrus, in accordance with Mr. Peary's instructions, were secured during the next four days, and returning to Etah, Saturday morning, Aug. 12, our disappointment at seeing the *Fram* in the outer harbor was soon changed to keen satisfaction at the discovery of the *Windward* safely anchored well within the protecting hills of the fiord. August 12 and 13 were devoted to visiting and preparations for the next chapters of the work, and on Tuesday the *Diana*, with Mr. Peary on board, left for a round of all the native settlements of Whale Sound, to gather equipment for next year's work, the *Windward* remaining for a walrus hunt in the waters off Etah and its vicinity. The *Diana* visited in succession the settlements at Cape York, North Star Bay, Saunders Island, Keati and Netilumi, killing nine walrus in Wolstenholme Sound and about 500 guillemots on Saunders Island.

We met the *Windward* according to programme on Monday, Aug. 21, at Northumberland Island, and learned that she had landed twenty walrus at Etah. Sixty

tons of coal were transferred during the day from the *Diana* to the *Windward*, and at 7:30 P.M. the ships parted company exchanging salutes, the former homeward bound, and the latter to remain a week longer completing her work. Kangerdlooksuah and a deer hunt at Academy Bay, five fine animals being killed, occupied Aug. 22 and 23, Olriks Bay, Karnah, and the Robertson Bay villages, the 24th and 25th, and at 6 o'clock on the morning of Saturday the 26th a brief call by a boat party having been made at the site of Polaris House, Lifeboat Cove, the final return to Etah, for winding up matters, was made.

All day Saturday every man on board was diligently employed in discharging our cargo of provisions, nearly all of which, sufficient for the remaining years of Mr. Peary's work, were put on shore, and in taking on coal from his stock to offset the *Windward's* draft on ours. On Sunday the natives ballasted the *Diana*, the sloop *Senta* was beached and shored up for the winter, the last letters and instructions were written, and at 1, Monday morning, the *Diana* cast loose and proceeded out of the fiord, homeward bound, and amid hearty cheers, the firing of guns and the dipping of flags on ship and shore.

The native allies having been landed at Robertson Bay, Northumberland and Saunders Islands, departure from Cape York was taken at 4, Tuesday afternoon, for Disco. On Saturday, Sept. 2, by permission of the Danish governor, and with the assistance of Eskimos, twenty-five tons of coal was taken from the Kudliset deposits in the Waigat strait; on Saturday, Sept. 9, fifteen more were bought at Battle Harbor, Labrador, and at 3 o'clock on the morning of Tuesday, Sept. 12, the *Diana* dropped anchor at Sydney.

The cruise of the *Diana* was in all respects successful, and in some, remarkable. More than 5,000 miles of steaming were accomplished in fifty-two days, of which over 2,000 were north of Cape York, all without detention from ice or accident of any kind. Melville Bay was crossed Aug. 2 and 3 in twenty and a half hours, actual running time, the shortest passage on record.

Most important and gratifying, however, was the ample proof afforded by two weeks' constant association, of the excellent condition, physical and mental, of Mr. Peary and his associates; of the thorough good feeling between him and his native allies; of his deep appreciation of the support and confidence of the Club, and of his firmly established conviction of most important results to be achieved with the returning spring.

HERBERT L. BRIDGMAN,
Secretary Peary Arctic Club.

In concluding his lecture Mr. Bridgman presented in detail the existing condition and immediate future of the Peary Arctic Club's work. President McKinley, a few days since, signed the bill directing an American register to the *Windward*, now at St. Johns, N. F., completing repairs to her hull and engines. Under command of Capt. Samuel W. Bartlett she will sail from Sydney for the North early in July. The term of the voyage depends almost entirely upon Mr. Peary and his work. This done, the ship will return in the autumn; otherwise she will be detained. Abundant equipment—pemmican and ammunition, lumber, oil, coal, dog food, etc.—will be taken in accordance with Mr. Peary's requisition of last year, but of food for himself and his party he has ample supply, the *Diana* having left nearly forty tons at Etah, his winter quarters, in August.

Permission to land at the Greenland ports was granted to the *Windward* by the Danish Government only on condition that she carried no tourists. As to Peary's success in the attainment of the Pole, the most confident hope was expressed. His last words on parting at Etah in August were: "I believe I shall win." And against the recent public prediction of the commander of the Lady Franklin Bay Expedition that Peary will fail, was placed the letter, almost on the same day, of Capt. John Bartlett, who wintered with him on the *Windward*: "I expect that Peary is now at Cape Hecla, drying out his clothes and getting his teams ready for the start North." Peary's own plans for the spring, stated in his letter to President Jesup, Aug. 28, 1899, were as follows:

"After careful consideration I have decided to make no attempt to winter the coming season at Fort Conger, and when this reaches you I shall be settled at Etah for the winter. Two things control this decision; first, the uncertainty of carrying dogs through the winter, and second the comparative facility with which the distance from Etah to Fort Conger can be covered with light sledges. Of sixty odd dogs which I had when the *Windward* reached Cape D'Urville in August, 1898, only seventeen were alive March 1, and these too were useless for work; my experience in this is the rule and not the exception. No expedition has wintered in this region without having its dogs reduced during the dark months anywhere from 50 per cent. to practical extermination. With the usual perversity of such things it is almost always the best dogs that succumb while the poorest survive. Wintering at Fort Conger, I would have in the spring a few haphazard survivors of my full pack. Wintering at Etah, I shall have in the spring my pick of the best dogs of the Whale Sound tribe. With all necessary stores at Fort Conger for the northern trip; with ample caches of supplies from Cape D'Urville to Conger, and with my present knowledge of the region, I can go from Etah to Fort Conger with light sledges in ten to twelve days at the outside, and as the sun returns ten days earlier at Etah than at Fort Conger I shall really lose nothing in point of time. The distance between Cape D'Urville and Conger has been covered in nine days, six days and five days. I could have fixed a team of dogs and a driver, that I have no doubt would have covered the distance in three days. The Eskimos coming to the ship this spring usually came from Etah in three marches.

I shall take with me as far as Conger in the spring a large supporting party of natives, most of whom I shall send back at once with instruments, etc., while some will remain there during my absence north hunting and getting out the contents of the north lean-to.

My movements beyond Conger will depend upon existing conditions next spring. I may pursue my original plan of following the North Greenland coast to its terminus and then making straight for the Pole, or I may take the route I propose for this spring, namely direct from Cape Hecla."

Letters to Lieut. Peary were dispatched by the whalers from Dundee, Scotland, about May 1, for delivery at Cape York, from which point the natives will attempt to carry them to their destination—a route never before attempted, and which Peary will also try to utilize in the opposite direction.

TROPICAL HURRICANES.

BY

F. J. B. CORDEIRO, Surgeon, U. S. Navy.

The Caribs, who dwelt in the West India Islands long ago, before the coming of the white man, had a word in their tongue which has come down to us and passed into many languages. It is "Hurakan." In the China Seas they speak of a "Typhoon." The Samoans have their own word for it, and so on through every tropical country. These words all mean in the original a mighty wind, and refer to the same phenomena.

Now that we have possessions in the West Indies our attention has been called especially to that peculiar and complicated storm known as the tropical cyclone. For the first time American soil has been swept by its full fury, and our weather observers who have during the past year been distributed around the Caribbean Sea have had an opportunity of chronicling, if not the most severe, yet probably one of the most destructive storms that has ever visited these regions. During the past 300 years, 355 such hurricanes have been recorded; but these were only those of exceptional severity. It is as mathematically certain as the laws which govern them that they will continue to recur on an average of several every year, as long as the West Indies exist. It is interesting to conjecture here what would have been the result had Columbus encountered one of these storms on his first voyage of discovery. Had he passed through the "eye" of a severe hurricane it is extremely doubtful if his frail caravels could have weathered it, and the discovery of the new continent must have been delayed many years.

The hurricane of August 7, 8, 9, 1899, was like all others, differing only in degree. The author was on the southern coast of Santo Domingo at the time. Early on the morning of the 7th, long, heavy swells began coming in from the eastward, which was the method the storm used to telegraph its approach.

As these long ocean waves may travel with a velocity of 80 or even 100 miles an hour, while the storm itself seldom travels more than 20 miles an hour, it will be seen that its arrival may be anticipated a day or more in advance. In the afternoon of the 7th a telegram was received from Washington, saying that a hurricane

somewhere to the eastward of Dominica was approaching that island in a westerly and somewhat northerly direction. If there had been any doubt as to the meaning of the long swells coming from the eastward all was now clear. The probable course of events could be forecast as follows—not from any special knowledge regarding cyclones (for our knowledge as to their laws has been hitherto singularly deficient), but because year after year they carry out the same programme, almost without variation. The wind would blow from the eastward of north, through north to southwest; the barometer would progressively fall, afterwards rising to about its original level. The track of the storm would be to the westward and northward. It would pass over Porto Rico by Turk's Island, sweep the Bahamas, and recurving somewhere about latitude 30°, would roll up the coast of the United States and out to sea, and then finally be dissipated. In the wake of the "Freight Train" the afterswirl would follow, and a persistent southeast wind could be expected. Martinique, Guadeloupe, St. Thomas, Montserrat, Porto Rico, Santo Domingo and the Bahamas, would be likely to suffer more or less damage according to the severity of the cyclone. And we know now that all this is what practically took place.

What the battering-ram effect of wind striking with a velocity of 80, 100, 125, or even 150 miles an hour is, and what the inundating effect is of the tremendous precipitation caused by cyclones, and of the tidal waves which the low centre may carry along, we have lately seen, and have seen many times in the past. The hurricane of October, 1780, called the Great Hurricane, was very similar to the recent one in many respects. While the loss of life in Porto Rico was appalling, it cannot be compared to the loss caused by the cyclone at Barisal and Backergunge, in India, in June, 1822, when more than 50,000 lives and a vast amount of property was destroyed. The West India hurricane of August, 1873, killed more than 500 people, damaged, stranded or wrecked more than 1,000 vessels, besides doing an enormous amount of damage to buildings on shore. Such is the terrible and extraordinary interest these phenomena possess for us.

It will be interesting to attempt to trace the course of a hurricane from its birth to its end. It must be premised that the sun, in its course round the earth day after day, heats a broad zone of the atmosphere directly under it. The air, becoming rarified by this excessive heat, rises directly upwards, very much like the hot air in a flue. This zone is known as the doldrums, and is about 10° wide. From the north and the south surface currents of cold

air rush in to fill this void, which, owing to the revolutions of the earth from west to east, gives a northeasterly direction to the wind coming from the north and a southwesterly direction to the wind coming from the south. When the sun is to the south of the Equator, a corresponding state of affairs exists, the doldrums being bordered by the southeast trades on the south and by the northeast trades on the north, which become northwesterly after crossing the Equator. These so-called trade-winds, with the interlying zone of doldrums, follow the sun north and south of the Equator. A tropical cyclone always originates in the doldrums, and it may start over land or sea. If the surface of the earth were covered with water alone, it would be difficult to see how a hurricane could arise, since, the conditions being uniform everywhere, there would be no determining point from which it could take its origin. With land scattered about it is a different matter. Since the specific heat of water is much greater than that of land, the heat pouring down from the sun raises the underlying islands to a much greater temperature than the surrounding water during the day, and since during the night the land cools more rapidly, we have generally a "low" over an island during the day and a "high" during the night, which give rise to the sea-breeze of the day and the land-breeze of the night, so well known in the tropics. It is easy to see how a "low," arising over a sufficiently large island, could give rise to a very respectable cyclone.

Where, as in the recent cyclone, the "low" originated on the sea (to the eastward of Dominica), it is possible that a cause lay in the great ocean current coming up along the coast of South America, or a heavy precipitation of rain at this point freeing a vast amount of latent heat, and, by relieving the atmosphere of the pressure of a large amount of aqueous vapor, causing a diminution in the pressure that started the phenomenon. It seems hardly necessary to speculate further on how "lows" of unusual dimensions may be formed—on the contrary, it seems wonderful that they are not formed oftener.

However that may be, we will simply suppose that a barometrical depression of unusual proportions occurs suddenly at some point. The wind from all surrounding points immediately begins to rush towards the vortex. Since the air in the doldrums is usually calm, it must have the same revolutional velocity as the part of the earth over which it lies. Consequently, all the air coming from the southward will be deflected to the eastward of the centre, and all the air coming from the northward will be deflected to the west-

ward, and a whirlwind will be formed which must revolve contra-clockwise. It will easily be seen that this is a general law for the northern hemisphere, viz., that every "low" in the northern hemisphere must result in a contra-clockwise vortex, while every "low" in the southern hemisphere must cause a clockwise vortex. Conversely, every "high" in the northern hemisphere must cause a clockwise whirl, while the opposite is true for the southern hemisphere.

We have, then, a phenomenon the counterpart of which is seen in the water flowing out of the drain-pipe of a bath-tub; or, more exactly, in the whirl of leaves on a gusty autumn day; or in a water-spout, which is a miniature cyclone.

Our cyclone is now formed. Before it starts off on its journey, let us survey it carefully.

The diameter of a cyclone may be anywhere from 100 to 1,000 miles, and its height from 20 to 40 miles. As the air is drawn in by a central attracting force, it follows approximately the so-called laws of Equal Areas, viz., a line connecting a given mass of air with the centre will describe equal areas in equal times. The general form of the whirl is as shown in Figs. 1, 2 and 3, Fig. 1 being a vertical view, and Figs. 2 and 3 being horizontal projections.

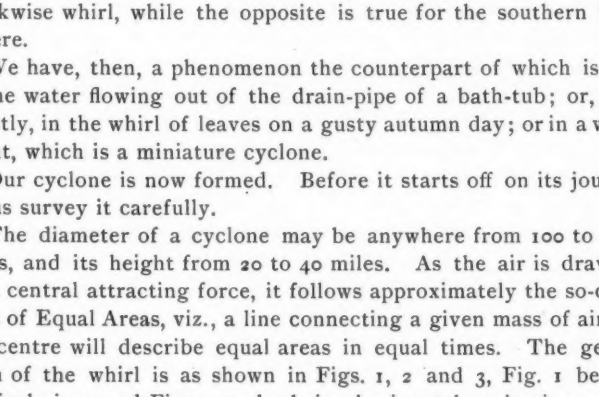


Fig. 1

It will be seen that a portion of air moving with comparative slowness at first, as it falls into the outer edge will gradually increase in velocity until it reaches the narrowest part of the "hour glass," which is some distance above the surface of the earth.

The highest surface velocities are not far from the axis and are usually 80 to 100 miles an hour—a force which few objects can withstand. It will be seen from Fig. 1 that "axis of the storm" is

a more correct term than "storm centre." The barometrical pressure across such a cyclone can be well seen by examining the accompanying pressure gradient. It will be noticed that we have come to speak of our cyclone as an entity by itself, totally different from the surrounding air. Since its parts preserve their distances and relative relations it may, for all intents and purposes, be regarded as a solid body of equal mass rotating with its average velocity. This does not mean that the same air always constitutes the same cyclone, for such is not the case. The identical particles of air that caused so much change in Porto Rico are not transported to the Bahamas to continue their work there. On the contrary, this air, after having been "through the mill," is left high above the earth not far from where it was originally derived. It is like a rotary snow-plough, where, though the mass in rotation is constantly changing, still an average energy of rotation is preserved.

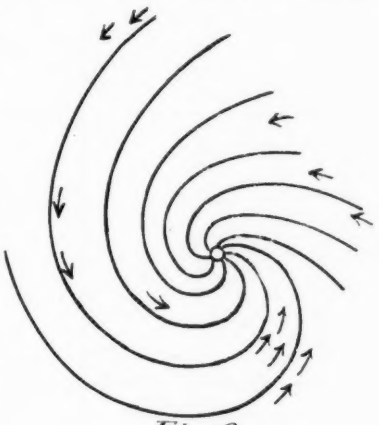


Fig. 2

The most important question of all from every point of view, both practical and theoretical, now awaits us, viz.: Why does the cyclone move and what are the laws governing this motion? Up to this time this part of the problem has been considered inexplicable. It will be seen that if the laws governing revolving storms (and all storms are revolving) were understood, and this knowledge could be applied to predicting their paths, meteorology would advance with one bound from scientific guesswork to an exact science. If the path of a cyclone can be pre-

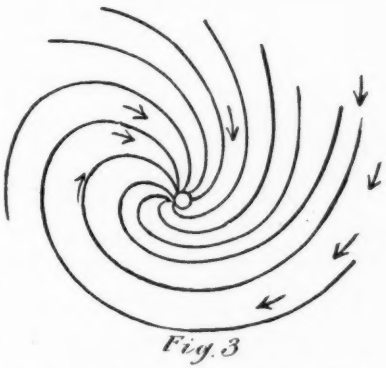
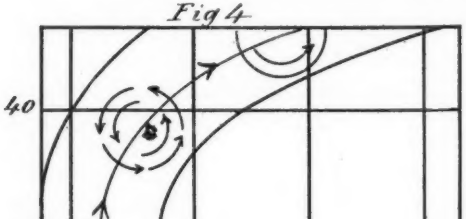


Fig. 3

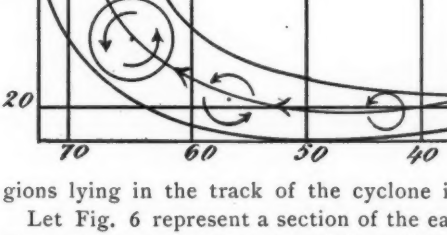
dicted from its "elements" with the same accuracy as the path of a comet, then the science of meteorology acquires a dignity commensurate with that of astronomy. I believe this point has been reached. Given a cyclone with a known "moment of inertia," of a known mass, rotating with a mean angular velocity at a given latitude and longitude, and its path and subsequent motion may be determined. The importance of this knowledge to all regions lying in the track of the cyclone is evident.

Fig 4



Let Fig. 6 represent a section of the earth through its axis and C a cyclone at the extremity of the radius OC rotating in the northern hemisphere contra-clockwise. Since the radius OC rotates with the angular velocity of the earth, our cyclone may be regarded as an ordinary gyroscope. As the average velocity of the air of which the cyclone is formed is that of the surface of the earth under its axis, we may consider merely the motion of a gyroscope OC moving about a fixed point O or an imponderable axis OC.

Fig 5.



It is not the intention of the author to give the complete analysis of the motions of a gyroscope under the given conditions, since this

is professedly a popular article. The object is simply to elucidate the subject to the non-mathematical mind.

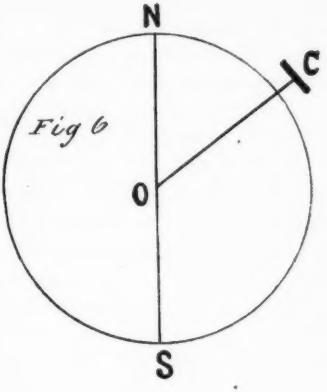


Fig 6

To the reader with a slight knowledge of mathematics, it will be sufficient to say that the gyroscope is an instrument that develops a deflective force normal to the plane in which it is turned. For instance, if our cyclone is turned with the earth, it will develop a deflective force, tending to increase its latitude, and a certain velocity will be developed towards the pole.

This velocity likewise will develope deflective force, tending to increase its longitude.

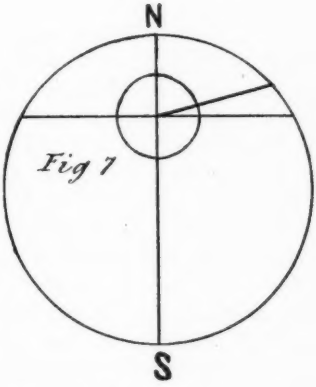


Fig 7

Let x represent the longitude and y the latitude of the axis, and suppose an initial impulsive velocity equal to the velocity of the earth at the point be given to the cyclone. Considering only a portion of the spherical surface small enough to be regarded as plane, we have as the equations of motion:

$$\left(\frac{d^2y}{dt^2}=k\frac{dx}{dt}\ \&\ -\frac{d^2x}{dt^2}=K\frac{dy}{dt}\right)$$

since the normal deflecting force is proportional to the angular velocity. Integrating these equations we get as the curve of motion $x^2+y^2-2\frac{Vo}{k}y=o$, which is the equation of a hyperbola situated vertically, with the origin at the upper vertex. It may be remarked that k above is equal to $\frac{CW}{RM}$ where R is a radius of the earth, and C, W and M are respectively the Moment of Inertia about the axis, the angular velocity and the mass of the cyclone.

It will be seen, therefore, that if the earth were at rest, and the cyclone given an initial velocity equal to its actual rotational veloc-

ity and started from a point P, it would describe the curve PH, which is for a small surface a hyperbola, as drawn in the figure with P the initial point at the vertex. Since no work is done the living forces must remain constant. Therefore

$$\left(\frac{dx}{dt}\right)^2 \mathrm{Sin}^2\vartheta + \left(\frac{d\vartheta}{dt}\right)^2 = \mathrm{Const.}$$

In other words, the gyroscope or cyclone will travel in the curve with a constant velocity equal to that originally impressed upon it. To obtain the actual path of the cyclone, we must compound the above motion with the motion of the earth about the axis. It is readily seen that the cyclone, starting out with the same velocity as the point of the earth on which it rests, gradually lags behind and goes to the northward. As it moves in the right-hand branch of the hyperbola PH it finally reaches a point where its velocity is equal to that of the earth. Here it stops going to the westward; shortly beyond its velocity becomes greater than that of the earth, owing to the diminishing circles of latitude. Here it moves to the eastward, but during the whole of its motion continually makes northing. The arm of the hyperbola being regarded as a straight line, which it may nearly be, it will be seen that the velocity to the northward is tolerably constant, while the velocity to the westward is constantly retarded and that to the eastward constantly accelerated; so the curve of the cyclone on the earth's surface must closely resemble a parabola, with the axis east and west. It is well known that a body moving with a constant velocity in one direction and with a constantly accelerated or retarded velocity in a direction at right angles must describe a parabola—a projectile, for instance. And such, in fact, do we find to be the actual paths taken by cyclones. The above is a rigidly exact explanation of the path of a cyclone, which has been a sore puzzle ever since it was first observed. Compare the paths delineated in Chart I and II from Piddington's Sailor's Hornbook. It will be seen that these paraboloid curves all have individual differences, depending upon differences in C, W and M, and the latitude and longitude where they started. That the path

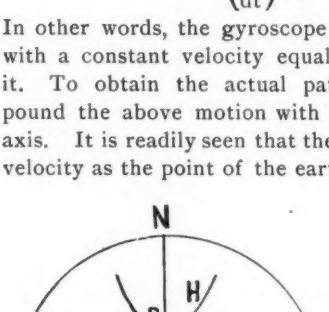


Fig 8

can easily be calculated from the "elements" is now clear. The meridian where it will recurve, its velocity at any point, and in fact anything about its subsequent motion can be predetermined. As to its velocity, it will be seen that if the generating hyperbola is very broad, so that the branches tend to coincide with the parallel of latitude on which it rests, the velocity may be very slow, but it never can be stationary. Some authors have spoken of stationary cyclones. Mathematical analysis shows that such a thing is impossible. When the branches are very narrow there may be a high velocity. As a matter of fact the observed velocities have ranged from 3 to 50 miles an hour or even more.

It remains to explain the observed broadening out of cyclones as they progress. This is on the same principle as a snowball increases in size by rolling. They are rolling stones that gather moss. The tendency of this is to destroy the original motion of rotation and lead to their dissipation. This is further helped along by friction on the surrounding air and on the surface of the earth. The continual precipitation of rain leads to the escape of a constant supply of latent heat, which acts in the axis like a flue and has a continual "winding-up effect." How far these antagonistic forces balance each other it is impossible to say. They frequently have energy enough to keep under way for two weeks or more, though many die out in a week and the feeble ones in a few days.

Much condensation is a concomitant of most cyclones, as might be expected when saturated vapors are exposed to various temperatures and pressures. In a waterspout the hot saturated air of the central shaft is surrounded by the cold spiral of the external air, and condensation results; but the water here is wholly fresh. There is no sucking up of the sea water, appearances notwithstanding.

These tropical cyclones, as has been said before, are not limited to the West Indies, but are found in the doldrums everywhere especially where there is a mixture of land and water. The author has been in four of these storms—three in the West Indies and one at Apia, Samoa. Two of these were axial. The subjective and objective symptoms are the same in all. The last sunset before the storm has a peculiar look, which can best be described as "oily." There is no mistaking such a sunset when once seen before. These storms last three days, as a rule, at the same point. The circumference is cloud-capped, but the axis is usually clear. An absolute calm exists in the axis, which lasts only for a short time (one hour or more). Here are found mountainous, confused seas, which are very dangerous—more dangerous, in fact, than the winds.

When coming upon indications of an approaching cyclone at sea, the navigator can usually, from the direction of the wind, determine his position relatively to the path of the storm, and lay his course so as to escape as much of it as possible. Since the axis travels at little more than steamship speed on an average, he will usually be successful.

On land these storms cannot be avoided, and should be met by prudent anticipation. Areas of land that have been inundated and are liable to be inundated again should not be built upon. But human nature is much the same, whether in the United States or Porto Rico. When a hurricane revisits any place it usually finds the same work to do over again.

In recapitulating it will be seen that when the "elements" of a storm have suitable values, it may never recurve, though this is almost always the case. A cyclone has never been known to cross the Equator; the above analysis shows that such a result is impossible. The above laws apply to any storm at any point of the earth's surface. The only difference between a tropical cyclone and other atmospheric disturbances lies simply in the superior energy of the former; and the energy of all is seen to be derived directly from the sun.

In summing up, we see that a "low" is formed by the sun at some point determined by local conditions. Owing to the rotation of the earth on its axis, a whirlwind must result contra-clockwise in the northern hemisphere and clockwise in the southern hemisphere. The energy of the whirlwind will be proportional to the difference of temperature of its parts, as is the case in all heat engines—and a cyclone may be regarded as a heat engine. A cyclone having its own proper rotational velocity, combined with a rotation about the axis of the earth, is a gyroscope simply, and obeys all gyroscopic laws.

It has long been a source of wonderment that the cyclone should move, just as for years it was considered a paradox that when acted upon by gravity the gyroscope should sustain itself and not fall to the ground. Some idea of the force impelling it may be formed by considering the cyclone as a solid wheel revolving about its axis. If all the axles in the world were welded together into one, it would be unable to hold the cyclone to a fixed point.

The independent motion of a gyroscope, acting under the two rotational forces described above, is in a hyperboloid curve, *i. e.*, it is as close an approach to an hyperbola as it is possible to describe

on a spherical surface. We may call this curve a "Spherical Hyperboloid."

This independent motion of its own, combined with the revolution of the earth on its axis, gives us the path of the cyclone as traced on the surface of the earth. This path resembles a parabola with its vertex pointing to the west. According to the conditions of the problem, the axis of the spherical paraboloid may deviate somewhat to the northward (or southward) of a strictly east and west line. The detailed analysis of the problem, together with the computation formulæ, would be out of place in any other than a mathematical journal.

THE TERRITORY OF ANADYR.

(From the Russian of E. Olssufjev, by E. Bondy.)

The territory of Anadyr occupies an area of irregular form of about 567,000 square miles, having a peninsula in the east, the so-called Chukchi Peninsula. The country is divided into three parts—the northern, which is almost uninhabited, and has been but little explored; the eastern, consisting of Chukotski Noss, and the southern, which occupies the valley of the Anadyr River. The last forms a broad, partly hilly territory, and is surrounded by mountains, which approach each other more and more as the river nears its mouth, and almost enclose it at that point. From about the middle course of the Anadyr the tundras are covered with low bushes, dwarf larches, cedars and willows, and towards the east even this sparse vegetation ceases.

The aspect of the country about the Novo Marinsk Post is especially dreary, for there is nothing to be seen but a vast expanse of greyish-yellow hills, covered with moss, though along the upper course of the Bielaja and its branches some poplars are found, and there is a surplus of good timber along the upper course of the rivers. This can always be counted upon to supply the demand along the lower course of the Anadyr.

The Anadyr rises in the Stanovoi Mountains, and as far as Jaripol it has the appearance of a large mountain stream. Here it is joined by the Pelidon, and attains a width of 170 metres, and the current becomes so strong that it is exceedingly difficult for a boat to make its way to Jaripol from Markovo.

The depth of water in the lower course of the river varies between two and four and a half metres, but near the mouth it does not exceed one metre.

Below the confluence with the Krasnaya there are formed on both banks peninsulas of sand, which make natural harbors for the boats, though even here, owing to the strong winds, navigation is not without danger.

The river water is not drinkable opposite the Novo Marinsk Post, as it is already mixed with the sea water, but near Point Kedrov it becomes drinkable at low tide. Near the so-called American Neck of Land the water still has at times a bitter taste, but above this point the influence of the sea water is not noticeable. Sweet water, however, is obtained from the tundras and from the thick layers

of snow which lie piled up as high as ten or twelve feet along the banks; these are drifts made by the winter storms and they never disappear before the end of August.

The ice of the Anadyr generally begins to move between the 1st and the 13th of June, but for a month before that time ice-holes begin to make their appearance.

Little is known of the Krasnaya and Bielaya Rivers, which empty into the Anadyr, as they have never been explored; but judging by the reports of the Chukchis, they must be streams of considerable size.

Neither do we possess much information about the Chukchi Peninsula, except that it is perfectly barren, and that the northern coast is indented and cut by many gulfs and bays.

The climate of the Anadyr territory is less severe than its latitude might lead us to expect. The western part, indeed, is influenced by the climate of the continent, but the softening effect of the Pacific Ocean is felt in the east. In Markovo spring begins on the 1st of June; while near Novo Marinsk the river at this time is still covered with ice, and a change does not take place before the end of the month.

THE POPULATION.—The Russians live in the village of Markovo and in small settlements near by. Markovo is situated on the left bank of the Anadyr, *i. e.*, on its middle course, and consists of 41 houses and 340 inhabitants. This is the winter residence, but in summer the people remove to other places, about twenty-five miles away. The whole population speaks Russian, and knows no other tongue.

They all belong to the parish of Markovo, and they are divided into three classes—the rich; the middle class, mostly employees of the rich; and the very poor. Most of them live in huts, but the poor in tents, after the fashion of the Yakuts. The richest only have glass windows in their houses, others use blocks of ice in place of glass.

The rich have wooden floors in their homes, and are provided with chairs, a table and a bed. The poor have just a few benches along the wall. In one corner there is a shrine; in another the fireplace. Several of the poorest families live together in one hut, the roof of which extends about one yard above the surface of the earth, as the interior is dug into the ground. The small windows hardly admit any light. Reindeer skins are spread on the ground, but there is no furniture at all. The tenants of this abode hardly find room to sleep.

There are no fences around the houses, but only a shed for keeping fruit some few feet away.

There is but one tent in Markovo; but in the smaller settlements there are more of these, as the people are poorer on the whole. In summer the people sit in the dark to protect themselves against the gnats, which are attracted by the lights.

The dress of the people is very much like that of the Chukchis, which has been adopted by all the Russians of Northern Siberia.

There are different types among them. Some show strong signs of Russian blood; others, descendants of the Tchuvassis, have long flat faces, protruding cheek bones, small black eyes without eyebrows, and thick lips; far from good-looking and strongly recalling the Mongolian type. A third type, descendants of the Yukagirs, have quite expressive eyes and more finely developed features; they are well built and the women are fair. The entire population lives principally on fish and reindeer meat, with a little game. They are used to eating a great deal, and cook from three to five times in the twenty-four hours. Brick tea is a necessity for them; but only the rich can afford to have bread and salt, and provisions are kept more by cold than by salting. Brandy was unknown among these people until quite recently, as it was a prohibited article; but since it now can be obtained by procuring a license, unlimited qualities are consumed. This habit exercises a very demoralizing influence on the people, for as soon as the inhabitant of the north has felt the effect of liquor he knows no moderation in using it, and will ride any distance to obtain it.

About May the ice begins to move and the river water to rise. Gradually the banks are overflowed, and in a short time Markovo and its surroundings are inundated. The people do not mind this, as they are fully prepared to move, and soon go to their summer homes in rowboats. They choose a spot which is convenient for fishing, this being their principal means of gaining a livelihood, and they also devote themselves to the breeding of reindeer during the summer months.

July is the time for red fish or sturgeon, and at this time the hardest work is accomplished. If the fish are plentiful the wealth of the people is assured for the year; if scarce, they move on and seek a better spot. The condition of the rich as well as the poor is terrible if no fish are caught at all, as is sometimes the case.

Kennan describes the terrible condition of the Markovzys in the year 1867 in his "Life in Siberia."

The reindeer hunt begins in August; by September the principal work is over and the people return to Markovo.

A brisk trade takes place in December in the nomadic camps of the Chukchis, for then the merchants return from the Gischiga fair, and a lively exchange of wares, furs, and domestic articles takes place, as money is not in use with them.

Concerning the character of these people, only good can be said of them. Their active life, which calls for long journeys coupled with great privations, has developed in them great ingenuity and a spirit of enterprise. There is a strong feeling both of friendship and kinship among them, and also a love of work.

The family ties are very strong and the father is the ruling lord of the home. Marriages are made exclusively by the will of the parents. Illegal children are born, though this is not considered sinful; yet the women are generally faithful. The people are ideally honest, theft is unknown and fighting is tabooed; neither do they know of social games, plays or dances.

Reading and writing are not yet general among them; but they are all religious, and the clergy are highly respected. Regarding the state of health of the inhabitants of Anadyr, the women have been found subject to nervous diseases and the men suffer a good deal with rheumatism. Cases of scurvy seldom appear. Since a few years a doctor makes annual visits to Markovo, each lasting several days; and every five or six years a surgeon appears on a vaccinating tour. The people themselves devote their time to the study of medicine, or rather the art of healing, which has been handed down to them from the Yakuts and the old Russian population.

GEOGRAPHICAL RECORD.

COLONIES OF THE UNITED STATES.

THE TELEGRAPH IN THE PHILIPPINES.—The United States Signal Corps has in the past two years erected or laid 2,500 miles of telegraph and cable lines in the Philippines. About 7,000 messages are sent over these lines every day. The plans, as far as outlined, contemplate the connection of Manila by wire with the most important points on all the larger islands between the north end of Luzon and the north coast of Mindanao, a north and south distance of about 750 miles. Two lines of wires now extend from Manila to the north coast of Luzon, one skirting the west shore and the other passing northward through the ricefields of Central Luzon and the rich tobacco district of the Rio Grande de Cagayan to the tobacco port of Aparri. Twenty short lines have been built between the central trunk line in Luzon and important towns east and west of it. Sections of the trunk lines are now in operation in most of the larger islands. Thus, while the development of the system in Luzon is far towards completion, over 150 miles of land wires are now in service in Panay, about 100 miles in Negros and 50 miles in Cebú. With the aid of the British cable to Cebú only about 160 miles of land wires and cable are now required to place Manila in touch with north Mindanao. The first cable in the system to connect all the islands has been laid between Cebú and Leyte. The first purpose of these lines was, of course, to serve American military needs, and they are commercially used very little as yet, but such use is hoped for in a few months.

MAPPING PHILIPPINE WATERS.—Secretary of the Navy Long sent a communication to the Senate in May on the necessity of an immediate survey of Philippine waters, as the existing charts fail to indicate many dangerous reefs, and are otherwise deficient. The present Philippine charts, all of British, Dutch and Spanish origin, are adequate only in respect of the approaches to a few of the larger ports, like Manila, Iloilo and Cebú, which are engaged in direct international trade. But there are many minor ports which will be the only outlets for the products of their districts until railroad building is largely developed. The hemp, tobacco, rice and other products of these districts are collected by small steamers that ply solely in the island trade. Not a few of these little ports,

at the head of narrow and rock-strewn channels, are not easy of approach, and the service of local pilots is imperative, for there are no charts. Owing to the exhaustion of the supply of Manila hemp in this country our gun-boats were ordered, early this year, to open the hemp ports, where thousands of bales of this fibre were stored. In February seven of these ports were again made available for commerce. In carrying out this work our vessels picked their way carefully along the channels, one of which, however, was not entered, as no pilot could be found. Not only good charts of the harbors and coast-lines are needed but also exploration of the coast waters for the discovery of menaces to navigation, such as the reef that wrecked the cruiser *Charleston* last year.

Hydrographic Work of the Coast and Geodetic Survey.—Nine vessels of the United States Coast and Geodetic Survey are now engaged in hydrographic operations. The sphere of service of the Survey has been extended by the acquisition of the colonial possessions. Three vessels have been employed on the coast of Porto Rico, where the surveys are nearly completed. It is expected to continue the surveys along the Hawaiian coasts until all portions that are of commercial importance are completely charted.

SOUTH AMERICA.

Exploration of the Upper Xingú.—Dr. Hermann Meyer, in 1896 and 1897, made a very fruitful journey in the upper basin of the large Xingú tributary of the Amazon. He returned to this region in 1898 and 1899 to map the sources of the river. According to his report on the result of his latest work (*Verhandlungen* of the Geographical Society of Berlin, 1900, Nos. 2 and 3), the Xingú is formed by the union of five rivers, whose course is nearly parallel—the Kuluene, the Kulisehu, the Auiya, the Batony, and the Ronuro—which in their turn receive numerous tributaries, running much in the same direction as the principal arteries. These watercourses descend from the northern slope of the plateau which separates the basin of the La Plata from that of the Amazon. Although the areas drained are narrow, they receive such a quantity of water that they soon become deep rivers, more than 300 metres wide; and Dr. Meyer is of the opinion that clay deposits under the superficial gravel-beds prevent the water from sinking deeply. The Formoso branch of the Ronuro may be regarded as the head stream of the Xingú. Dr. Meyer descended the great rivers to the Amazon, meeting difficulties at nearly every step. Trees and other

obstructions impeded his canoes on the upper river, and the series of falls and rapids farther down exposed his expedition to many dangers. On the Ronuro Dr. Meyer met Indians who did not know the use of iron. The data he collected will greatly improve the mapping of the Xingú basin.

EUROPE.

GOLD IN LAPLAND.—*Le Tour du Monde* (May 19, 1900) says that the Norwegians have begun prospecting for gold in the Altenelv valley, about sixty miles south of Bossekop, in the heart of Lapland. The results thus far have been very satisfactory, and placer operations will be continued during the summer. The geological formation is similar to that of the Klondike region, and it is thought probable that it may contain large auriferous wealth.

RUSSIA'S ARCTIC HARBOR.—*La Géographie* (April, 1900) describes the development of Alexandrovsk, the town which was built by order of the Russian Government about two years ago on the Murman coast. Though situated north of the Arctic Circle, Catherine Harbor, on whose shore the town stands, is ice free, and the water is deep enough for the largest vessels. A wharf has been built out into the harbor about 500 feet. An aqueduct from a lake brings excellent drinking water to the town. Alexandrovsk now contains a population of about 250, mostly officials and laborers, 50 houses, a hotel and a few stores, and is lighted by electricity. Some colonists have settled in the place, and it is expected that most of the inhabitants of Kola, further south, will remove to Alexandrovsk, which has a better location and a milder climate. It is not expected that the town will have large growth until it is connected with St. Petersburg by rail. This road is certain to be built, and it is expected that the port will be the outlet for considerable merchandise from the interior of Russia, as it will have advantages over Baltic seaports, which are frozen over every winter.

ASIA.

THE NEW PORT OF SAN-TU-AO.—It is expected that the port of San-tu-ao, which the Chinese Government opened to commerce last year, will do a considerable business in the export of tea. The river valleys in that district are noted for the excellence of their tea crop. Heretofore coolies have carried on their backs the large tea exports from this region to Fuchau, four days' journey to the southwest. As yet, however, the port shows no indication of

rivalling Fuchau in tea exports, as very little commerce has passed through the new port in the past year. Some trouble, it is feared, may be caused by the coolie porters, who will lose their usual means of livelihood when vessels begin to load with tea at the new port.

VOLCANOES IN EAST SIBERIA.—The *Deutsche Rundschau für Geographie und Statistik* (May, 1900) reports the discovery of two volcanoes west of the Yablonoi mountain range, on the Vitim plateau. The volcanoes have been named in honor of the Russian explorers Muschketov and Obrutschev. The mountains are apparently situated over 100 miles to the north of the junction between the Trans-Siberian and the Manchurian Railroads and 150 miles east of the north end of Lake Baikal. No volcanoes have hitherto been reported in any part of Siberia, except in Kamtchatka, where there are a large number that are frequently in eruption.

AFRICA.

THE MOORE EXPEDITION TO TANGANYIKA.—The expedition in charge of Mr. J. E. S. Moore, which was sent from England last year to Lake Tanganyika, has completed its work and is now on the way home. It has proved that the ancient marine fauna discovered in Lake Tanganyika, which indicates the former connection of that lake with the sea, does not extend to any of the lakes situated further north. It has also ascertained that the lake formerly covered a large extent of country, both to the north and south of its present situation; also, that the longitudes previously computed for the lake are erroneous, and that most of it lies about 30 miles west of the position hitherto shown on the maps. The earlier mapping of the coast-lines is comparatively accurate, so that the shape of the lake on the new map will not differ much from the older delineation. But the lake will now be shown as having a more northeast and southwest direction. The map made by missionary Hore has for fifteen years been used in every atlas of Africa, but it has at last met the fate that usually overtakes the early surveys of every region. These pioneer maps answer their purpose very well until finally supplanted by more accurate mapping, the natural result of better instruments and more scientific methods.

GOLD IN KATANGA.—The Katanga Company of Belgium was organized to exploit that large district among the southern headstreams of the Congo known as the Katanga district. It has long been reported that this region was very rich in minerals, and the company expected to give most of its energy to mining. The re-

port of its exploring expedition, led by Mr. Lemaire, is disappointing. He crossed the whole region from the Luapula in the east to Lake Dilolo in the west, and then turning east again followed, for the most part, the water-parting between the Congo and the Zambesi. The geographical results of the expedition are of much importance; but Mr. Lemaire has discovered neither gold nor silver.

"All that has been said about the mineral wealth of Katanga," he writes, "is the pure product of the subjectivism which is characteristic of the accounts of many travellers."

All he found was a little copper and plenty of iron.

DR. ANSORGE'S TRIP ACROSS AFRICA.—Dr. W. J. Ansorge has just crossed Africa from the Indian Ocean to the mouth of the Congo. He made the journey from Fort George, on Lake Albert Edward, in Central Africa, to the Atlantic in 79 days, which is remarkably fast time considering that he passed entirely through the great forest belt, where travelling is slow and difficult. In the forest through which his course led to the northwest he met one of the pigmy tribes. When he reached the Ituri River, which is called the Aruwimi in its southern part, he descended it to the Congo, and steam accelerated his journey all the way from the upper river to the ocean. He made a fine collection of birds and butterflies, but it was naturally impossible for him to extend his collections in many other directions during so rapid a journey.

COMMERCIAL GEOGRAPHY.

EMDEN AS AN INTERNATIONAL SEAPORT.—The *Deutsche Rundschau für Geographie und Statistik* (May, 1900) says that the small city of Emden, which heretofore has had little importance except as a North Sea fishing port and the outlet for garden produce forwarded on small vessels to England, is about to become an important international port. The Government spent much money for its development in 1899, and the work is still in progress. Steamship communications with Danzig, Stettin, Königsberg, London and St. Petersburg are being established. Ample accommodations will be provided for large vessels. The Shantung Railroad Company, which is building a railroad in the Shantung province of China, about 300 miles in length, has stopped its shipments of steel and iron from Hamburg and Bremen and will transfer this business to Emden.

ELECTRICITY ON THE NILE.—*La Nature* says that the Egyptian Government, last fall, instructed Professor Forbes to study the

question of the industrial utilization of the cataracts. He spent the winter in upper Egypt and the Sudan. In his report he says that the first cataract at Assuan may be electrically employed to furnish power for the pumps used in the irrigation of lower Egypt, and to run the sugar and other machinery in upper Egypt. He believes also that the second cataract near Wady-Halfa may supply the necessary power to run the Sudan Railroad as far as Abu-Hamed; and that the trains from Abu-Hamed to Khartum may also be electrically run by means of generators installed at the fifth and sixth cataracts. Some other engineers are not so sanguine as Prof. Forbes seems to be of the possibility of utilizing the water-power of the cataracts to so large an extent.

Growth of Congo Commerce.—The expansion of business in the Congo Free State is almost unequalled in Africa. Exportations have doubled and importations nearly so since the opening of the railroad around the rapids only two years ago. The exportations last year amounted to $7,213,591. The exports in 1886 were only $177,286, and in 1896 they were $2,477,919—in other words, they have nearly trebled in value in four years; while the importations, which last year were $4,465,169, were more than twice as much as in 1893. The rapid growth of the rubber industry accounts chiefly for the increased commerce. The value of rubber exported last year was $5,794,701, the next most important item being ivory, $1,511,092; while palm nuts yielded $310,704, and palm oil was exported to the amount of $146,902. These were the only very important articles of export.

Diamonds in Brazil.—The diamond industry in Brazil is now carried on only by individuals or small companies working in a crude manner. The yield was never much over $1,000,000 a year, and the product is worth now annually less than $200,000. Still the quality of Brazil stones averages higher than that of the Kimberley output. Brazil gems rarely leave the country until they are ready for the jewellers, for they are cut either at Diamantina, Gouvea or Rio de Janeiro; while the Kimberley stones are sent in the rough to the London market in March every year, and are then distributed to the diamond cutters of Holland and Belgium. In 150 years of mining operations Brazil has yielded about $100,000,000 worth of gems, or a total output that is equalled every six or seven years by the product of the Kimberley mines. The total sales of African diamonds already exceed by millions the value of all the gems Brazil has produced, though African diamond mining has been carried on only about thirty years.

THE POLAR REGIONS.

SOME RESULTS OF THE BELGICA EXPEDITION.—M. E. Racovitza summarizes in *La Géographie*, No. 2, the work done in the Antarctic by the *Belgica*.

Palmer Land was found to be a vast archipelago of little islands. Hughes Gulf is the entrance of a strait which connects Bransfield Strait with the Pacific. This strait extends in a northeast-southwest direction from 63.51° to 65°, South Lat. The Pacific end, which is called Belgica Strait, is probably Dallmann's Bismarck Strait, erroneously placed by him too far to the south. Trinity Island is only the cape of a body of land to which has been given the name of Danco Land. This forms the eastern shore of Belgica Strait, and is nothing more than a continuation of Graham Land.

The sides of Belgica Strait are high and mountainous, with steep slopes and narrow valleys, and one peak appeared to be more than 2,000 metres in height.

The channels, which have great depths in the middle, lead through almost vertical banks, and the whole aspect is that of a sunken region in which the valleys have been invaded by the sea.

These lands are entirely formed by ancient crystalline rocks, granites, green stones and syenites. Gneiss was seen only at the mouth of the Pacific Strait.

In January and February some of the small islands were only partially covered with ice, while all those of a larger extent and Danco Land were completely covered with an immense crust of ice, which showed itself under three different forms. The interior was all occupied by a frozen sheet, which may be compared with the Greenland inland ice. Everywhere upon the mountain sides were suspended glaciers, and in all the valleys tremendous crystalline currents, which ran into the sea; alone the perpendicular cliffs showed a naked rock. The limit of eternal snow coincided here almost to a certainty with the level of the sea.

Another important geographical discovery is that of a continental tableland or plateau, situated between longitude 75° and 103° west of Greenwich, and from latitude 70° to 71° 35′ South. The mean depth in which it is is 500 metres, with an abrupt fall to 1,500 metres towards the north.

The depth of the continental plateau, generally placed at from 200 to 300 metres, shows that this region underwent also the depressive movement which was remarked in the lands of Belgica Strait.

The plateau rises gently towards the south and sinks in its eastern portion towards the north to connect itself most assuredly with

the continental plateau of Graham and Alexander lands. It must connect in a similar manner towards the west, 50° further, with the continental plateau discovered by Ross, east of Victoria Land. We should then have a continuous continental mass from longitude 50° west to longitude 60° east, and the discovery made by the *Belgica* gives support to the hypothesis of an Antarctic continent. The sediments contain, beside the gray slime, a very strong proportion of sand, gravel, and a very great number of pebbles of rounded form, which were certainly rolled by the sea. The transport of these materials must have been made by the ice. If this plateau indicates the existence of a continental mass south of the 72° parallel, inversely the driftway of the *Belgica* demonstrates the non-existence of the ice-wall signalled by Bellingshausen; and the same thing may be said of the land signalled by Walker, since we passed with the ice-drift over its supposed spot. The easy drifting of the pack towards the west renders impossible the presence of the land signalled by Cook towards longitude 105° west.

THE DANISH METEOROLOGICAL INSTITUTE has published information on the state of the ice in the waters east and west of Greenland in 1899. This information has been compiled by Capt. V. Garde, from observations by the captains of sealing and whaling vessels, from Danish functionaries in Greenland, from Admiral Makarof of the Russian Navy, from the meteorologists of the Swedish expeditions in the Arctic, and from the members of the Danish expeditions to the east coast of Greenland.

Six maps, one for each month from March to August, illustrate the report.

Capt. Garde's study of the observations brings him to the following conclusions:

(1) In the Kara-Sea, in the western part of Barents Sea, S. E., and partly N. of Spitsbergen and in Smith Sound, there has been more than the normal quantity of ice.

(2) South of Franz Josef-Land and on the east coast of Greenland there has been considerably less ice than usual.

In Davis Strait the conditions were nearly normal, and in Baffin Bay and Melville Bay the state of the ice was more favorable than in 1898.

The extraordinary scarcity of icebergs in the southern part of Davis Strait in the summer of 1899 is explained by the very great number of bergs (about 2,000) which were met with at Cape Farewell in October. These were undoubtedly the same that were ob-

served by Lieut. Amdrup in July, a little to the north of Angmagsalik.

It is thought that the spring season this year will be a favorable one on the south-west coast of Greenland.

The following telegram to the Brooklyn *Standard Union* was published by that paper on the 9th of June:

ST. JOHNS, N. F., June 9.

The Peary Arctic steamer *Windward* came out of the dry dock to-day, having fully completed the extensive repairs which have been in progress for several months, and will shortly leave for Sydney, C. B., in command of Capt. Samuel W. Bartlett, to take on coal and supplies for her voyage to the North. While the new engines desired have not been obtained, in consequence of the utter inability of manufacturers both in Great Britain and in America to take up the contract, a new shaft and propeller have been supplied, the old engines thoroughly overhauled and put in the best possible order, so that at least a knot and a half an hour in speed has been gained, bringing the *Windward* up to the *Kite* of the 1891–1892 and 1895 expeditions. In addition, the hull has been thoroughly rebuilt, strengthened, both within and without, and the *Windward*, as a whole, is in far better condition than she has been for years, new boilers having been installed by Mr. Harmsworth shortly before he turned her over to Mr. Peary in 1898.

The *Windward* will this year sail as an American ship, so far as her nationality is concerned, the necessary legislation by Congress having been approved by President McKinley, though, not having entered an American port, the formal register has not yet been issued. Capt. Bartlett has, however, a copy of the act, certified by the Secretary of the Treasury, upon which the United States consuls and foreign authorities of any port will permit the *Windward* to fly the Stars and Stripes. The rebuilt *Windward* will be, therefore, the first Arctic expedition steamer to carry the Stars and Stripes at the peak since the ill-fated *Polaris* left the Brooklyn Navy Yard in July, 1871, under command of Capt. Charles F. Hall, who died on board a few months later.

The expedition will sail from Sydney about July 1, and proceed directly, with a call at Disco, to Etah, North Greenland, Mr. Peary's winter quarters, where instructions from him will doubtless be found, or, if not, will be awaited. The *Windward* will take with her the maximum quantity of coal which she can carry; additional lumber, oil, sugar, arms, ammunition, provisions, scientific instruments, and everything which is necessary for Mr. Peary's work. The *Windward* also takes two new whaleboats, built at New Bedford, for the Peary service, thoroughly equipped in every detail.

It is, however, quite possible that Mr. Peary may have attained the Pole this spring, in which case he will, of course, return with the ship; if not, the additional equipment, with what remains of the forty tons of supplies left at Etah by the *Diana* last year, will be ample for the remainder of the time which he will devote to his work. Upon the arrival of the *Windward* at Etah, Mr. Peary will assume command, and her further movements will be subject to the conditions of his work and to his instructions. No passengers will be taken on the *Windward*, the Danish Government having qualified their permission to land at the Greenland ports with the condition that tourists should not be carried. Mrs. Peary and Miss Peary, however, will go North on the steamer as far as Etah, and it it probable that the *Windward*, if she returns will bring home the Robert Stein party, landed near Cape Sabine by the *Diana* in August last.

MAP NOTICES.

BY

HENRY GANNETT.

Since our last notice the U. S. Geological Survey has issued a number of new atlas sheets representing different parts of the country. Five of these are in New York State, all being upon the scale of 1:62,500, with contour intervals of 20 feet. Indian Lake represents an area in the southern part of the Adirondacks, including the lake of that name, embosomed in high mountains. The Tully, Cazenovia and Salamanca sheets represent portions of the dissected plateau toward the western part of the State; and the Silver Creek and Westfield sheets represent the shores of Lake Erie.

Parts of Ohio and Kentucky are represented in three sheets, known as the East and West Cincinnati and Ironton, on a scale of 1:62,500, with a contour interval of 20 feet. The last named lies almost entirely in Ohio, and represents a dissected plateau of no great relief. The others, which adjoin one another, represent the cities of Cincinnati, Covington and Newport, with adjacent portions of the two States. The general surface of the country is broken and uneven, with the Ohio River flowing mainly in a narrow valley; while the Great and the Little Miami, with sinuous courses, meander through broad valleys to their junction with the master stream.

In Illinois there is one sheet, Evanston, showing that suburb of Chicago and a portion of the lake shore.

In South Dakota there are two sheets, Spearfish, showing the northeastern slopes of the elliptical mass of the Black Hills, and Alexandria, representing a portion of the level glaciated valley of James River. The scale of these sheets is 1:125,000, and the contour interval 20 feet.

In Nebraska are two sheets, St. Paul and Sidney, on a scale of 1:125,000, and a contour interval of 20 feet. The first is traversed from west to east by Loup River, formed in the western part of the area by the junction of its north and south forks. These, with the main stream, flow in a broad valley, in gentle slopes, and are nearly graded. Platte River flows across the southeastern corner of the area in a valley of great width and extremely level. The area be-

tween the valley of this stream and the Loup is largely filled with sand-hills, while north of the Loup the country is somewhat broken, eroded prairie. Sidney sheet lies farther west. Its area is traversed from west to east by Lodgepole Creek, a tributary to the Platte, while across its northeast corner flows North Platte River. The area is mainly composed of a high, semi-arid prairie, breaking down toward the north in the valley of the North Platte in irregular hills.

In Idaho is one sheet, Sawtooth, on a scale of 1:125,000, with a contour interval of 100 feet. It is a region of high mountains, rising to altitudes exceeding 11,000 feet, and drained in the main by Wood, Boise, and Salmon rivers.

Among the special maps issued by this office is one designated Menominee. This includes a part of Dickinson County, in the Upper Peninsula of Michigan, in which are the mining towns of Iron Mountain and Norway. The types of topography occurring here are those produced by the erosion of the Laurentian Glacier—irregular, broken hills, crooked streams, with many lakes and marshes. The scale is 1:62,500, and the contour interval 20 feet.

The first of a series of land classification maps have been issued by the U. S. Geological Survey. These represent quadrangles about Seattle and Tacoma, Wash., and show, by tints and conventions, the areas naturally without timber, those covered with woods and with virgin merchantable forests; areas from which the forests have been cut, and those upon which they have been burned. The two latter classes are subdivided into those upon which forests are being restored or not.

Upon the backs of the sheets are printed short descriptions of the areas, and statistics of the different classes of land and the stand of timber.

These areas lie mainly along the west shores of Puget Sound, and were originally almost entirely covered with fine merchantable forests. Lying near the coast, they are among the most densely settled portions of the State, in which lumbering has been extensively carried on in wholesale fashion for many years. As a natural result, a large proportion of the territory has been denuded of its merchantable forests, and another large part has been burned by fires, which, starting invariably after cutting, have spread into the adjacent forests; but, owing to the heavy rainfall prevailing in this region, the destruction of the forests, whether by fire or the axe,

has been followed by a re-growth everywhere, excepting upon the cultivated lands.

It is, we understand, the intention of the Geological Survey to publish similar sheets of large parts of the United States.

Atlas de Finlande. Société de Géographie de Finlande. Helsingfors, 1899. 32 double folio plates.

This is a physical, statistical and industrial atlas of Finland. It contains a general map of the province, a relief map, showing elevation by shades of one color, in the manner commonly in use for that purpose; a petrographic map, showing the distribution of rocks; a Quaternary map, showing glacial erosion and deposition; a series of maps illustrating the elements of climate, and numerous maps showing the distribution of plants, together with forest distribution. Following these are many maps and diagrams exhibiting statistical facts relating to population, agriculture, mining and manufactures. The means of transportation are illustrated by maps, showing wagon roads, railroads, telegraph and telephone lines, with diagrams illustrating transportation statistics. The atlas closes with maps, showing the distribution of works of prehistoric peoples, and a series of historical maps of the country. Taken altogether, it contains a vast deal of information concerning a little-known part of the earth.

WASHINGTON LETTER.

WASHINGTON, June 20, 1900.

The geological and topographical surveys in progress in various parts of Alaska, under the U. S. Geological Survey and U. S. Coast and Geodetic Survey, are to be continued at three points during the ensuing season. The greater part of the work is in the Seward Peninsula, the large body of country between Kotzebue Sound and Norton Sound, forming the westernmost extension of Alaska. It is at present the focus of interest of the whole territory, since on one of its southern points lies the Nome district, and farther north, on the coast, nearly as far as Bering Strait, and opposite Port Clarence, the newly opened gold district of Cape York. Inland, still farther to the north, and in the direction of the neck of the peninsula, lies the unexplored extension of the Cape Nome gold-bearing belt.

The plans of the U. S. Geological Survey include the examination of the Nome region and environs and reconnoissances of the trend of the gold-bearing belt, working both from the north and south. Aside from work on the Seward Peninsula, the Geological Survey has placed a party in the Copper River district, and will store supplies on the Koyukuk River, in preparation for an Arctic exploration in the summer of 1901.

The Coast and Geodetic Survey is sending two steamers to survey the southern coast of the Seward Peninsula, and also two parties to different points on the southeastern coast of Alaska. The survey of the southern coast of the peninsula will be conducted by the steamer *Pathfinder* from Cape Nome to St. Michaels, and by the steamer *Patterson* to Cape York and Port Clarence. Especial attention will be given to the examination of harbor facilities for Cape Nome and Cape York. The work on Golofnin Bay, which was begun last year, will be completed, and the coast to the east examined by the *Pathfinder*. The work at Cape Nome is of special importance, because the region has not yet been visited by Government surveyors. The *Pathfinder* started from Seattle June 13, carrying, besides its officers, the members of the Geological Survey parties.

The Geological Survey force which is to work on the land area adjacent to the waters traversed by the steamer *Patterson* consists of a topographic party in charge of Mr. E. C. Barnard and a geological party under Mr. Alfred Brooks. The region covered by this party is the gold-bearing country in the southern part of the Seward

Peninsula, between Cape Nome and FishRiver and Port Clarence—an area of from three thousand to four thousand square miles. It is to be surveyed on a scale of 4 miles to the inch, producing a map similar to that of the Fortymile Quadrangle surveyed in 1898. A complete triangulation from Golofnin Bay to Port Clarence is to be carried through for the benefit of the Coast and Geodetic Survey. The party under Mr. Brooks will make a reconnoissance of the new Cape York district, a special study of the extent of the gold-bearing formations, and the condition of occurrence of veins from which the placer gold of the foothills and river valleys back of Nome is derived.

The great gold-bearing belt whose southwestern termination has been opened up in the vicinity of Nome appears to extend across the Seward Peninsula in a general northeasterly direction towards the Good Hope Bay and Keewalik River. The party which has for its especial object the reconnoissance of this belt will be landed on Good Hope Bay by one of the Coast Survey steamers as soon as the ice breaks and will then work southward. It consists of Mr. W. J. Peters, topographer, and Mr. W. C. Mendenhall, geologist. They will survey the northeastern part of the Seward Peninsula, returning across the neck by Buckland Bay to Norton Bay.

Last season the headwaters of the Koyukuk and Gens de Large rivers, in the comparatively unknown northwestern part of Alaska, were explored by a Geological Survey party. It is proposed to prepare this summer for exploration in 1901 of the country lying within the Arctic Circle, between the Koyukuk and the Arctic Ocean. In order to accomplish this object, it is important to leave the Yukon sufficiently early in the season to return before the ice closes in the fall. If supplies are cached on the Koyukuk this season, a party with a light outfit can come in by sledge the following winter, ascend the rivers on the ice early in the spring, and come out after the ice is broken up. The supplies are to be stored at the mouth of the Allenkakat River, which is just within the Arctic Circle, and the proposed route follows up the Allenkakat to the divide by which it heads against streams flowing north to the Arctic Ocean. Thence the party will proceed down some stream to the ocean and along the coast west and south until picked up by a steamer.

In the southeastern part of Alaska the Coast and Geodetic Survey will have the steamer *Gedney* doing coast pilot work, and a party under Mr. H. D. Ritter at Prince William Sound. The latter will carry on triangulation, coast-line surveys and hydrographic work.

During the summer of 1899 indications of copper were discovered

by the Geological Survey party which made a reconnoissance of the headwaters of the Copper, Tanana and Nebesna rivers. The chief copper districts are the valley of the Chettyna, a western tributary of the Copper River, south of the Wrangel Alps, and the region about the headwaters of the Copper and Nebesna rivers north of the Wrangel Alps. This season a topographical and geological survey will be made of the Chettyna River district. It is an area of 3,000 square miles, and the map will be on a scale of four miles to an inch. The party, which left Seattle on May 30, consists of Mr. T. G. Gerdine, and Mr. F. C. Schrader, geologist. This area will also be connected with the work done by the Coast and Geodetic Survey on the coast near Valdes, and a geological exploration will be carried through, if possible, between the valley of the Chettyna and the south coast parallel to it.

In the United States proper, the usual work of the Geological Survey will be continued in various sections, and in some localities the advance will be more rapid than usual, on account of co-operation with State surveys. Considerable work will be done in New York, Pennsylvania, Ohio and Maine. This latter State co-operated for the first time in 1899. This is also the first season that Ohio has co-operated, and plans are made for the completion of one or two atlas sheets in that State. Plans for co-operation with California are to be placed before the State Legislature next winter. One work of especial interest is the continuation of the survey of the line between Idaho and Montana, from the international boundary to the crest of the Bitterroot Mountain range.

On the eastern shore of the country the Coast and Geodetic Survey will carry on coast and harbor examinations at four points. The steamers *Eagle* and *Bache* will work in Chesapeake Bay. The *Bache*, until July 1, will survey the lower part of the bay, conducting a hydrographic examination from the mouth of the Potomac to the capes, preparing the triangulation as a base for topography. In June the *Blake* came up from Porto Rico, where she has been engaged all winter, and will conduct a survey on Savannah River. The Savannah Bar will be examined and a deep-waterway sought. The *Matchless*, also from Porto Rico, will conduct an examination of the old channel entrance to Charleston Harbor. Some work will be done also at Portsmouth Harbor.

On the west coast of the country, Puget Sound at Seattle and Port Townsend will be examined by the *Gedney* before her departure for Alaska, and the steamer *McArthur* will examine the bar outside the Golden Gate at San Francisco. On August 1 a party will be

sent to carry on hydrography and topography at the mouth of the Columbia.

The western forest reserves, of which an examination has been carried on during the last three seasons by the Geological Survey, under the charge of Mr. Henry Gannett, will be further studied this season. Over half of the total area of the reserves has now been examined, and a report of the work during the season of 1897 has appeared as Part V of the Nineteenth Annual Report of the Survey. The results of the work of the season of 1898 are in the hands of the public printer, and a report of the work of 1899 is in course of preparation. Last season the whole of the Lewis and Clark Reserve was examined, and the Mt. Rainier Reserve completed. Work was also done in the Olympic, the southern part of Cascade and Ashland reserves, and an examination was made of the Yosemite National Park and Stanislaus Forest Reserve, which adjoins the park on the north. The present season's work will be to examine the country north of the Stanislaus Reserve. From this region the timber was removed during the early mining days in California, and it is especially desirable to determine to what extent new growth is coming up. Other regions which will be examined this season are the country between the Mt. Rainier and the Washington reserves in Washington, with a view to reserving also that area and so including the whole Cascade range. The examination of the Olympic Reserve will also be completed this year.

The Division of Forestry of the Department of Agriculture, during the present season, will be concerned largely with the effect of sheep pasturing on land which is suitable for the growing of timber. Mr. Gifford Pinchot, the Chief of the Division, is making an examination of various lands in which sheep are pastured in Arizona and New Mexico, hoping to establish beyond a doubt whether or not land is rendered worthless for subsequent growth of timber by sheep pasturage, and how much the young growth is injured by the passage of the flocks. Other parts of the Western States are being examined by Mr. Pinchot's assistants.

The water resources of the United States are also being studied systematically by the hydrographic branch of the Geological Survey. The appropriation for this purpose has been increased from $50,000 to $100,000, and a number of important reservoir sites will be surveyed in the West, in addition to the stream measurements carried on throughout the entire country.

The demand for official data concerning the available water

power on various rivers is notable as showing the rapid utilization of these, especially through electrical transmission of power. Examinations have already been begun of the headwaters of Kings and San Joaquin rivers in California, Truckee River in Nevada, and Milk River in Northern Montana. Close co-operation is had with the Forestry Division in the study of the effect of forests upon the water supply, and for this purpose a joint reconnoissance is being made of the southern Appalachian forest area; the character of the forest growth and its value is being determined by the Forestry Division, and the volume and fluctuation of the rivers issuing from its area is being studied by the Division of Hydrography.

N.

THE RESULTS OF THE CUBAN CENSUS.

BY

HENRY GANNETT.

The main results of the Cuban census taken last October have been given to the public in the form of three bulletins, by the director, General J. P. Sanger. These contain the figures and a discussion of the more important aspects of the population. The first bulletin relates to the total population, showing the increase and decrease since the last census taken by Spain, the density of population and its urban and rural elements. The consideration of these statistics is prefaced by an account of the division and organization of the island for local government. Bulletin No. II presents the statistics of nativity, birthplace, citizenship, sex, conjugal condition, age and literacy. The third bulletin gives literacy and citizenship statistics in detail, and was made up especially in connection with the recent municipal elections in Cuba.

The latest Spanish census of Cuba was that of 1887. By this count the total population of the island was 1,631,687. By the present census the total population was 1,572,797. The numerical loss in the twelve years amounts to 3.6% of the population in 1887. This is only a part of the actual loss, however, for allowance must be made for the normal increase of the population up to the beginning of the war. In reality a population of little less than 1,800,000 in 1895 was reduced in the following five years by the war and reconcentration policy to the present numbers—a loss approximately of 200,000 people.

The figures showing the distribution of this loss over the island and the distribution of the races and ages will be more easily appreciated if the political division of the island is understood. The whole island is divided into six provinces, these into 132 *términos municipales*, which may possibly correspond to counties, and these into smaller divisions termed *barrios*, which may be translated wards, and which number from eleven to twelve hundred. The province of Pinal del Rio, at the extreme western end of the island, is in part mountainous, and adjoins Havana, which is characterized by containing the large capital city. Matanzas on the east is followed by Santa Clara, both agricultural and rather thickly populated, and the eastern end of the island is occupied by the sparsely

populated and pastoral provinces of Puerto Principe and Santiago de Cuba. The municipal districts, into which these provinces are divided, are the principal administrative and political civil divisions of the island, and have been used as the census unit. The whole of each municipal district is divided into barrios in such a way that no distinction is made between the cities and the rural districts, and this has led to some difficulty in defining the limits of cities.

The loss of population has not been distributed evenly over the whole island, but on the contrary three of the provinces have gained in numbers since 1887. These are Puerto Principe, which increased 30.2% of its population in 1887; Santiago, which increased 20.3%, and Santa Clara, which increased 0.7%. Certain districts in other provinces showed a decided increase, among them the municipal district of Havana, which contains the city. This district gained to the extent of 20.7%; while the province outside the district of Havana suffered a loss of 15.2%. Pinar del Rio and Matanzas, on either side of Havana province, lost respectively 23.4% and 21.9%. In general, the part of the island which sustained the heaviest loss was that in the region of the centre of hostilities. The gain in the eastern part was due to its being at a distance from the scene of the struggle, and also probably to the migration of people away from the western provinces. The gain in Havana district was caused by the reconcentrados, who were collected from the surrounding rural parts of Havana, Matanzas and Pinar del Rio, and the great loss in these provinces is due to their almost complete depopulation at that time.

The average number of inhabitants to each of the 44,000 square miles of Cuba is 35.7, which is about the same density as the State of Iowa. Great diversity in this respect is seen among the several provinces, whose density of population varies from eight inhabitants to the square mile in Puerto Principe to 153 in Havana. The density of the rural population, when cities of 8,000 inhabitants or more are omitted, ranges from 6 in Puerto Principe to 55.3 in Havana province. Santiago has a scant rural population of only 21.7 to the square mile, and Matanzas and Pinar del Rio, on either side of the thickly populated Havana, have densities of 39 and 32.8 respectively. Puerto Principe is the principal grazing region; Matanzas and Santa Clara contain most of the great sugar plantations, and Pinar del Rio is the principal region of tobacco culture.

The number of large cities in Cuba has always been remarked, but the high percentage of the population which the returns of this census have shown to be urban is a matter for surprise. Cuba

has a larger proportion of its people living in cities of 8,000 and over than the United States, 29.2% of the population of this country belonging to this class in 1890, while in Cuba the proportion is 32.3%. Including all cities down to 1,000 inhabitants 47.1% are urban in Cuba. In the different provinces this proportion varies from 77.4% in Havana, 51.2% in Matanzas and 40.1% in Puerto Principe to 33.2% in Santiago and only 12.9% in Pinar del Rio. The number of cities of 1,000 inhabitants or more, which it is possible to give separately, is 96. Of these 16 have a population of 8,000 and over, 5 a population in excess of 25,000, and one, Havana, a population of 235,981.

To Bulletin No. I is appended Table I, which gives the population of Cuba by provinces, municipal districts and barrios, and Table II, containing a list of the cities of 1000 and over, with their populations.

The results of the census concerning race, sex and age of the Cuban people have brought out most interesting conditions. The whole population has been divided into five race and nativity classes, viz., native whites, foreign whites, mixed, negro and Chinese. The present census establishes the fact that in every province in Cuba the native whites are in a majority. This fact has an especial bearing on the suffrage restrictions which have been made in the island, and it has been fully discussed in Bulletin No. III. Native whites are, proportionally, especially numerous in Puerto Principe, the pastoral province, and in Pinar del Rio, parts of which are rather inaccessible to the colonizer. In the city of Havana, owing to the large element of foreign birth, they formed a trifle less than half, 49%. The native whites are 57.8% of the total population, the colored, including mixed, amount to 32%, the foreign-born to only 9% and the Chinese to less than 1%. The colored element is less strong than has been supposed, and the records show that the proportion has steadily decreased in the last hundred years, as in the United States. Forty years ago the colored population is known to have been three-fourths males, and by the present census it is more than half females. The early excess of males was due, of course, to the constant supply of male slaves brought in, and the present population consists of a new generation, which is in the normal ratio. The colored were in largest numbers in Santiago, where they were 45%, and least numerous in Puerto Principe, which contained 20% colored. In Havana city they were 27.3%. The Chinese also have steadily decreased—from 34,834, in 1861, to 14,857 at present. The foreign-born are

centred in Havana city, in which they are 22.4% of the entire population. They grade away from the city in the following ratios: 8.8% in the rural portion of Havana province, 7.5% in Matanzas and 6% in Pinar del Rio; in Puerto Principe the proportion is very small, and in Santiago it is only 4%. The key to the situation is found in the fact that the Spanish population, which is three-fourths of the whole foreign population of the island, is also concentrated in the city of Havana, being 20% out of the total of 22.4% foreign-born; the proportion of the foreign born which is not Spanish steadily increases with remoteness from Havana. The fact is, the Spanish came to the island principally in political interests and the other foreign whites for commercial and agricultural purposes. The figures on citizenship appear rather diverse when compared with the race statistics: 83% of the entire population claimed Cuban citizenship, only 1% Spanish and five per cent. other than Spanish or Cuban; 11% were recorded as being in suspense, having not yet signified their intentions. Apparently 5% out of the 88% of the Cuban-born are citizens of other countries, being the children perhaps of foreign-born, and only 1% out of the 9% of Spanish birth are Cuban citizens, the remainder being classed mostly with those in suspense. The foreign citizens were bunched in Havana city and the purest Cuban citizenship was found in Santiago. Citizens of countries other than Cuba and Spain were twice as numerous in the rural part of Havana province as in the city [11.6% as opposed to 5.3%].

A constant characteristic of the population of Cuba since 1775, as quoted by Humboldt, has been an excess of males, caused by the fact of the island's belonging to the class of countries exploited to a large extent by foreigners. In fact, the only races showing an excess of males are the foreign white and the Chinese; the mixed, negroes and native whites all having an excess of females in the census of '99. This race distinction is further emphasized by the fact that since 1887 the number of males and females have apparently changed in opposite directions, that of the females increasing 14,924 and that of the males decreasing 51,202. The loss of males is due, of course, partly to the return home of foreigners, driven away by the disturbances, although reduction in the number of native males, consequent on the war, has had its share. The excess of males is greatest in those western provinces where the foreign element is strongest. The total excess of males is 57,613, or 3.6% of the entire population. Cuba differs from Jamaica, Porto Rico and the Bahamas in this respect and resembles the United States.

The conjugal condition of the Cubans is characterized by a smaller proportion of married than any European country or the United States. There is present also in Cuba a third class, which is found in some Catholic countries where canonical marriage is difficult and expensive, that is, people participating in unions by mutual consent only. By the present census for the first time this class has been recognized and the statistics counted in with the true marriage statistics. The proportion of those participating in these unions varies from 4% of the total population in Puerto Principe to 12% in Santiago, and varies indirectly as the percentage of regular marriages, which range from 12.4% in Santiago to 19.5% in Puerto Principe. The two classes together give a married population of less than one-fourth [24.1%] for the whole island—a proportion much smaller than in the United States, where it was 35.7%, and even smaller than in the State which had the lowest percentage, Arizona, with 30.7%.

The age statistics are found to emphasize strongly the effects of the island's painful struggle. Not only is there a large deficit in children born in the last five years, but adults and old people are in smaller than normal numbers. These deficiencies follow the gain and loss in numbers of the total population. The percentage of children under five varies from 11.1% in Puerto Principe and 9.8% in Santiago to 7.9% in Matanzas and 7.3% in Havana. In the city of Havana it was 7.6%, and in the rural portion of the province it was only 7.1%. The average for the whole island was only 8.3%; while in Jamaica it was 13%, in Barbados 13.6%, and in the United States 12.2%; from the figures of the last Spanish census of Cuba, which gave age statistics [that of 1861], it is possible to estimate the normal percentage in Cuba of children under five, and this is found to be 12% of the total population. This indicates "a deficiency of about 60,000 children under five, which must be attributed to recent events in the island." The deficiency in old persons is due to other causes than the war.

"The per cent. of the population belonging to this group was 14.2, while in the United States it was 17.2. But this relatively small number of elderly persons in Cuba is not a new characteristic. Indeed, in 1861 the proportion was somewhat less. It probably results from unsanitary conditions, ignorance regarding care of health, and poverty, all of which are widely prevalent among certain classes in the island. These causes operate to produce short average duration of life, and have perhaps been reinforced by another, the depletion of the age class of over 45 among the foreign-born through their return to Spain, China or elsewhere after their work in Cuba is over."

The percentages in the age groups of from 17 to 20 and 21 to 44 are about equal to the same in the United States, and that there is

a deficiency in these groups appears only from the fact that the age groups of under 5 and over 45 are also small. The age group which appears to have suffered least from the war, and which comprises four-fifths of the extra percentage, is that of school age, 5 to 17.

"These children represent the survivors of those born in Cuba between 1882 and 1894, together with a negligible number of immigrants."

They were 35.2% of the entire population, and, compared with the same class in the United States, would give 119 children where the United States would give 100. They appear to be distributed among the provinces much as are the children under five, except that it is Havana city that has the fewest instead of the province outside.

In connection with this class of children of school age, which is so large at present in Cuba, it is of interest to examine the school and literacy statistics. Only 16.3% of these children attended school the year of the census. The proportion of the total population over ten years of age who could read was 43.4%—rather more than two-fifths. Comparing this with the percentage of literates in the last two Spanish censuses of Cuba, it is found that there has been a steady increase:—1861, 19%; 1887, 28%; 1899, 36%. The illiterates are distributed in the provinces according to the percentage of urban population, and vary from 38.8% in Havana and 50.9% in Puerto Principe to 65.8% in Santiago and 76.2% in Pinar del Rio. In Bulletin III the literacy of the male population of voting age is shown by race and nativity, and is found to be distributed as follows: of the white Cuban citizens 51% were unable to read, of the colored Cuban citizens 74% were unable to read, and of the Spanish citizens 12% were unable to read. This disparity between the races is not enough, however, to give the foreign voters a majority in any of the provinces. It has been found safe to abide by the provisions of the election laws, which gave the suffrage only to those who could read and write, or to owners of $200 property, or to soldiers in the Cuban army. The following table sums the subject up.

Proportion of literate males of voting age who were born in Cuba to all literate males:

[Province.]		[Province.]	
Havana City	45%	Havana [excluding city]	66%
Pinar del Rio	59%	Santiago	70%
Matanzas	61%	Puerto Principe	76%
Santa Clara	63%		

BOOK NOTICES.

The Norwegian North Polar Expedition, 1893–1896. Scientific Results, edited by Fridtjof Nansen, Volume 1. Published by the Fridtjof Nansen Fund for the Advancement of Science. Christiania, Jacob Dybwad; London, New York, Bombay, Longmans, Green, and Co.; Leipzig, F. A. Brockhaus. 1900.

Dr. Nansen says in his preface :

> In order to place the various Memoirs before the scientific world at the earliest possible date, they are printed as they are finished, without regard to the systematic sequence, and they will be published as soon as there is sufficient material to form a volume. Each Memoir will be paged separately, and will be given a number, running continuously from 1 through the whole series, by which it may easily be referred to.

This first volume contains five Memoirs: a description of the *Fram* by her builder, Colin Archer; the Jurassic Fauna of Cape Flora, Franz Josef Land, by J. F. Pompeckj, with a Geological Sketch of Cape Flora and its Neighbourhood by Fridtjof Nansen; Fossil Plants from Franz Josef Land by A. G. Nathorst; An Account of the Birds by Robert Collett and Fridtjof Nansen; and the Crustacea by G. O. Sars. In all, there are forty-six plates.

It is estimated that the work, which will be issued only in English, will form five or six quarto volumes, and will be finished in the course of about two years.

It is Dr. Nansen's intention to give, at the close, a complete summary of the scientific results.

As a specimen of printing the book deserves the highest praise, and the text is remarkably free from errors of the press.

Glacières or Freezing Caverns. By Edwin Swift Balch, A.B. (Harvard); F.R.G.S., Member of the Franklin Institute, of the Appalachian Mountain Club, etc. Philadelphia, Allen, Lane & Scott. 1900.

Mr. Balch first became acquainted with subterranean ice in September, 1877, while descending King's Ravine, on Mount Adams, in the White Mountains of New Hampshire.

Since that happy day he has visited ice-caves in various countries and has made notes of his reading on the subject, to the advantage of those who look into his handsome book.

The first hundred pages are devoted to what are called Experi-

ences in Glacières, well described and illustrated by cuts from photographs and drawings of sections.

Sixty pages are devoted to a discussion of the causes of subterranean ice, with a preliminary consideration of the terminology of the subject. Mr. Balch finds that, so far as he knows, the only correct, generic term for subterranean ice-formations is the French word *glacière*, and he goes on to say:

> It might be well, therefore, if the French term *glacière* were adopted as a generic term for all underground ice-formations. As, however, there is little likelihood of this happening, the question arises as to the best English equivalent or equivalents.

The French word seems to be in the way of adoption. It is familiar to English scientific writers, and it is recognized by at least three authorities: Stormonth's Dictionary, the Century and the Standard.

The popular belief that the ice of caves is formed in summer and melts in winter is partly founded on the fact that the temperature of caves is colder in summer and warmer in winter than the outer air. It is to be remembered also that the *glacières* are rarely visited in the winter season. Prof. Thury, intending to visit one cave in mid-winter, was told that he would lose his time, for there would be no ice in the cave. He went by himself and found the *glacière* full of hard ice. His report staggered the peasants; but one of them at last spoke for all:

> "It makes no difference; in genuine *glacières* there is no ice in winter."

The list of *glacières*, pp. 165–265, is made to include too many mere names, with the added remark: *No information.*

These and the notices of subsoil ice in the tundras of Alaska might have been omitted with advantage.

A bibliography and an index bring the work to a close.

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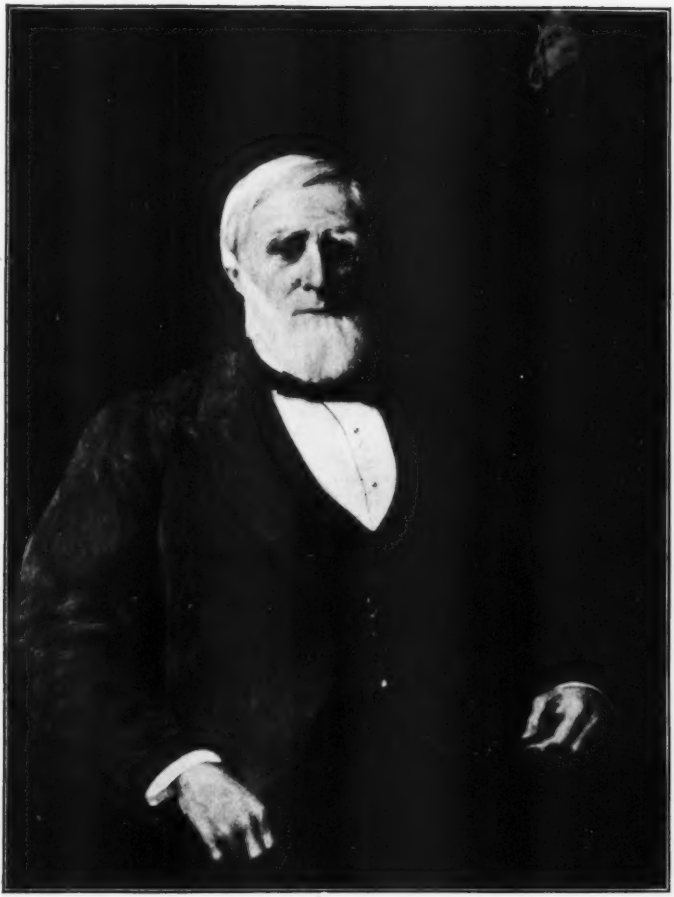
From Robert T. Hill:

Map of Texas and Parts of Adjoining Territories, compiled by and under the Direction of Robert T. Hill. U. S. Geological Survey, Washington, 1899.



CHARLES P. DALY,

PRESIDENT OF THE AMERICAN GEOGRAPHICAL SOCIETY,

MAY 5, 1864—SEPTEMBER 19, 1899.

From the portrait by Harper Pennington.